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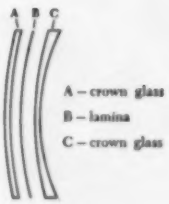

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| 40 | 18 20 22 |

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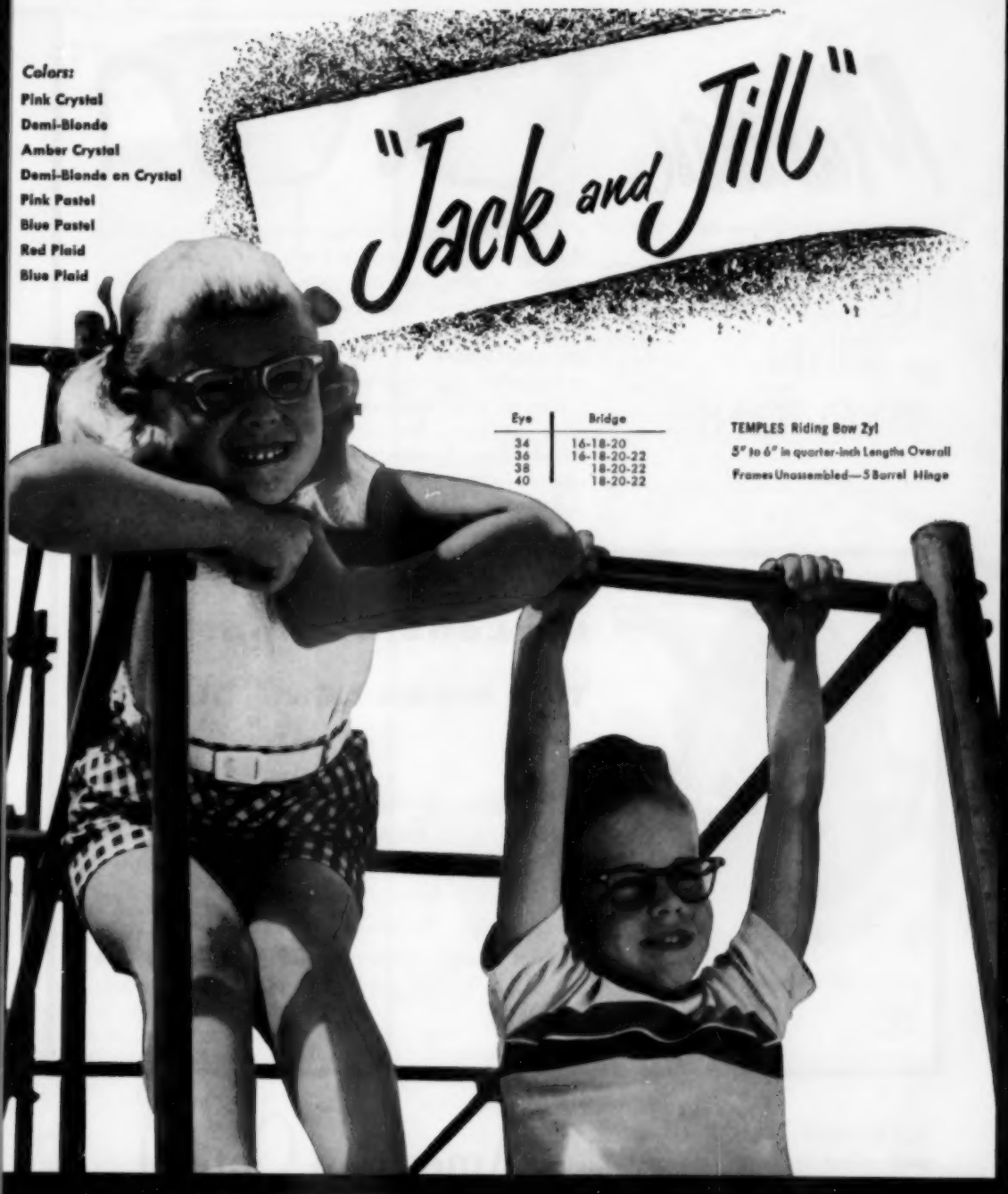


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Blue Pastel
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|---|---|
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| 36 | 16-18-20-22 |
| 38 | 18-20-22 |
| 40 | 18-20-22 |

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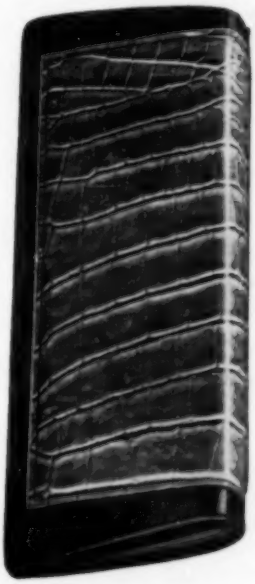

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Vol. 31 August, 1954 No. 8

# THE VARIATION IN THE ACCOMMODATIVE-CONVERGENCE ACCOMMODATION (ACA) RATIO UPON PERIODIC RETESTING*

Leo Manas†
Chicago College of Optometry
and
Paul Shulman‡
Northern Illinois College of Optometry
Chicago, Illinois

## INTRODUCTION

Borish[1] in discussing the research of Hofstetter on the zone of clear single binocular vision concludes that, "The slope (ACA ratio) does not vary with training." Morgan[2] in presenting a case to illustrate the effect of plus acceptance training states, "Now the question arises as to whether there has been any basic change in the ACA ratio. This can be determined by again examining the ratio of the changes in phoria with the add. . . . Thus there has been no basic change in the ACA ratio. What has occurred as a result of training is that the base-out-to-blur finding has been increased . . ."

Stein and Hofstetter[3] in their investigation of the effect of prolonged television viewing on certain optometric findings included in their data the measurement of the ACA ratio by the method of Morgan and presented additional data in their Table VI so that the ACA ratio could be computed by the method of Fry. We have tabulated these average values in our Table I. From these data we see that the average range in ACA ratio units as determined by the method of Fry is 1.5, and the range is 2.4 units when the ACA ratio is determined by the method of Morgan.

Heath and Hofstetter[4] state that the ACA ratio does not vary with training and present a study of the effect of orthoptics on the zone of binocular vision in intermittent exotropia. They include a series of nine examinations of the patient and conclude, ". . . These examinations show an apparent decrease in the ACA ratio, an apparent reduc-

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†Optometrist. M.A., Member of faculty.
‡Optometrist. Member of faculty. Fellow, American Academy of Optometry.

TABLE I

The Effect of Prolonged Television Viewing on the ACA Ratio as Determined by Calculation (Fry) and by Direct Measurement (Morgan) Based upon Data Obtained by Stein and Hofstetter*.

| Subject | ACA Ratio (Fry) Mean | Std. Dev. | Range | ACA Ratio (Morgan) Mean | Std. Dev. | Range |
|---|---|---|---|---|---|---|
| G.H. | 3.0 | 0.85 | 2.4 | 2.6 | 1.02 | 3.0 |
| G.C. | 3.2 | 0.27 | 0.8 | 2.6 | 0.80 | 2.0 |
| A.K. | 2.3 | 0.50 | 1.4 | 2.6 | 1.20 | 3.0 |
| C.P. | 5.5 | 0.46 | 1.2 | 3.8 | 0.95 | 2.0 |
| A.M. | 1.7 | 0.64 | 1.6 | 2.0 | 0.63 | 2.0 |
| | 3.1 | 0.54 | 1.5 | 2.7 | 0.92 | 2.4 |

*Abstracted from Table VI: Television & Optometric Findings—Stein and Hofstetter (Am. J. Optom. & Arch. Am. Acad. Optom., 28, 533, 1951.)

tion of the distance exophoria, and apparently unequal variations in the range of relative convergence for different levels of accommodation during the course of training. . . . The apparent decrease in the ACA ratio and reduction of the exophoria are attributed to the disappearance of this strabismic shift of the zone and to the increasing reliability and validity of the findings with training. . . . The position, slope, and width of the zone remain essentially unchanged. . . ." If we consider the four examinations of this intermittent exotrope as presented by Heath and Hofstetter and calculate the ACA ratio by the method of Fry, we obtain a range of 2.0 units (see Table II).

Hofstetter[5] states, "Assuming a linear correlation between accommodation and convergence, a straight line may be drawn in by inspection to represent the line of regression of the six findings. . . . The mean for the group is 2.60° per diopter of accommodation with a standard deviation of ± 1.17°."

TABLE II

The ACA Ratio of an Intermittent Exotrope While Receiving Orthoptics Based upon Data Presented by Heath & Hofstetter*.

| Date | 6/7/50 | 10/27/50 | 1/16/51 | 1/18/51 |
|---|---|---|---|---|
| 6M phoria thru subjective | 6 Exo | 8 Exo | 9 Exo | 11 Exo |
| 40cm. phoria thru subjective | 8 Exo | 12 Exo | 9.5 Exo | 10 Exo |
| ACA Ratio by method of Fry | 5.2 | 4.4 | 5.8 | 6.4 |

*The Effect of Orthoptics on the Zone of Binocular Vision in Intermittent Exotropia—A Case Report—Heath & Hofstetter. (Am. J. of Optom. & Arch. Am. Acad. Optom., 29, 12. 1952.)

Morgan[6] in his study of accommodation and its relationship to convergence states, ". . . The actual amount of accommodation as

measured on the haploscope is plotted against the values of convergence, found not to be associated with fusion. . . . It will at once be noted that these values fall upon a straight line showing a constant value for the accommodative-convergence ratio over the whole range of change of accommodation. For this subject this factor has a value of 4.2 prism diopters for each diopter of accommodation as calculated by the method of least squares. The average was 4.0 ± 1.5 diopters." Morgan[7] states, " . . . some fifty subjects over a period of several years have been given intensive training while some fifty others have been given training but not so intensive. . . . A control group receiving no training was also set up. The methods used are too varied to be discussed. . . . No significant changes (due to training) occurred . . ." The author listed the following optometric tests in which no significant changes occurred—ophthalmometry, static retinoscopy, subjective to best visual acuity, dynamic retinoscopy, and gradient.

It is the conclusion of the authors cited that the ACA ratio is a unique physiological constant for a particular individual; that this ratio is stable and does not vary with the accommodative level, age, or with extended visual training. This conclusion is maintained despite the experimental data of Hofstetter, Morgan, and Fry which reveal a standard deviation that is approximately 40% of the mean value of the ACA ratio.

The present authors determined to investigate the constancy of the ACA ratio for a group of experienced observers under controlled experimental conditions at a frequency of three times per week until a total of 20 measurements had been obtained by both the method of calculation (Fry) and by direct measurement (Morgan).

EXPERIMENTAL PROCEDURE

The 22 members of the Gamma Omega Phi Fraternity volunteered as subjects. The members of this fraternity are optometric students and thoroughly familiar with optometric testing procedures. Each subject was tested by the same examiner, using the same testing equipment, and at the same time of day. Each subject was tested three times per week at approximately two-day intervals until a total of 20 testing sessions had been completed. All subjects had 20/20 vision with correction lenses, and none showed any evidence of strabismus. The subjective refraction of each subject is presented in Table III.

Each testing session consisted of the measurement of the phoria at far (No. 8), the phoria at near (No. 13B) and another near point phoria test performed through a +1.00 D.S. add over the subjective. Each of the phoria tests was performed from the base-in prism direction

TABLE III
The Subjective Refraction of Each Subject.

| Observer | Subjective Refraction O.D. | O.S. |
|---|---|---|
| Rosen | +0.25 —0.50 x 95° | +0.50 —0.25 x 60° |
| Gould | —1.25 —0.50 x 90° | —1.00 sphere |
| Shane | —2.75 —0.50 x 170° | —2.50 —0.75 x 160° |
| Stein | Plano —0.25 x 160° | +0.25 —0.25 x 180° |
| Wasserman | —5.50 —0.75 x 95° | —5.00 —0.75 x 95° |
| Weisman | +0.25 —0.25 x 90° | +0.75 —0.75 x 65° |
| Silverstein | Plano —0.50 x 80° | —0.25 —0.25 x 120° |
| Parker | Plano —0.25 x 180° | —0.25 —0.75 x 180° |
| Liberson | —3.25 sphere | —3.00 sphere |
| Pitasch | Plano —0.25 x 90° | Plano |
| Greenfield | —1.00 —0.25 x 75° | Plano |
| Reyhan | +0.75 sphere | +0.75 sphere |
| Stern | +0.75 —1.00 x 165° | +0.75 —1.00 x 10° |
| Hartstein | —4.00 —0.50 x 140° | —4.00 —0.50 x 10° |
| Signer | —0.75 —0.50 x 90° | —1.00 —0.75 x 90° |
| Eichler | +1.25 —1.75 x 90° | +1.25 —1.50 x 85° |
| Pollack | —3.00 sphere | —3.00 sphere |
| Friedman | —1.75 —1.00 x 75° | —1.75 —0.75 x 110° |
| Miller | +1.50 —0.25 x 15° | +1.25 —0.25 x 10° |
| Teitel | —2.50 —0.25 x 105° | —0.25 —0.25 x 95° |
| Tashna | Plano | Plano |
| Lux | +0.50 —0.50 x 30° | +0.50 —0.50 x 165° |

and from the base-out prism direction. A total of six phoria measurements comprised one testing session. The test chart used for the phoria test at far (No. 8) consisted of a row of 20/20 Snellen letters at six meters from the subject. The test chart used at near consisted of a single vertical row of 20/20 reduced Snellen letters presented at 40 cms. from the spectacle plane. The targets were always presented at eye-level in the median sagittal plane of the head of the subject. The phoria tests were made by placing a 6Δ prism base-down before the right eye and a base-in prism before the left eye of sufficient degree to c.ate uncrossed diplopia. The subject was instructed to fixate the upper image continuously and to keep it clear at all times. As the subject followed these verbal instructions, the examiner slowly reduced the amount of base-in prism until the subject reported vertical alignment of the targets. The amount of base-in prism remaining in the horizontally oriented rotary prism is recorded as the degree of exophoria in prism diopters; if the prism was in the base-out position after the subject reported vertical alignment of the targets, esophoria was recorded. This same test was repeated, but with sufficient base-out prism placed in the horizontally oriented rotary prism to create crossed diplopia. The amount of base-out prism was slowly reduced while the subject maintained the upper target clear until vertical alignment was reached. This was recorded in the same manner as before. At all times the subject was

thoroughly familiar with the actual testing distance.

The testing sequence for one testing session was—(1) phoria at far (No. 8) from the base-out direction, (2) the same test performed from the base-in direction, (3) phoria at near (No. 13B) from the base-in direction (4) same test performed from the base-out direction, (5) phoria at near thru +1.00 D.S. O. U. above the subjective from the base-in direction and (6) same test repeated from the base-out direction. A typical raw data sheet is shown in Table IV.

TABLE IV
TYPICAL RAW DATA OF RESEARCH PROJECT
GAMMA OMEGA PHI FRATERNITY

Patient: Tashna Doctor: Rosen
SUBJECTIVE: O.D. Plano Time: 5:25
O.S. Plano P.D.: 63 m.m.

| Date | Hab. Phor. @ Far B.O. | B.I. | Aver. | Ind. Phor. @ Near B.O. | B.I. | Aver. | +1.00: Ind. Phor. @ Near B.O. | B.I. | Aver. |
|---|---|---|---|---|---|---|---|---|---|
| 2/23 | 6 X | 6 X | 6.0 X | 20 X | 18 X | 19.0 X | 19 X | 19 X | 19.0 X |
| 2/25 | 6 X | 6.5 X | 6.3 X | 10 X | 12 X | 11.0 X | 18 X | 17 X | 17.5 X |
| 2/27 | 6 X | 4 X | 5.0 X | 14 X | 16 X | 15.0 X | 18 X | 16 X | 17.0 X |
| 3/4 | 7 X | 6 X | 6.5 X | 14 X | 14 X | 14.0 X | 18 X | 17 X | 17.5 X |
| 3/9 | 6 X | 6 X | 6.0 X | 10 X | 10 X | 10.0 X | 14 X | 14 X | 14.0 X |
| 3/13 | 6 X | 6 X | 6.0 X | 13 X | 15 X | 14.0 X | 18 X | 18 X | 18.0 X |
| 3/16 | 6 X | 6 X | 6.0 X | 14 X | 14 X | 14.0 X | 18 X | 18 X | 18.0 X |
| 3/18 | 6 X | 6 X | 6.0 X | 14 X | 14 X | 14.0 X | 16 X | 16 X | 16.0 X |
| 3/20 | 6 X | 6 X | 6.0 X | 12 X | 14 X | 13.0 X | 18 X | 16 X | 17.0 X |
| 3/23 | 6 X | 6 X | 6.0 X | 13 X | 12.5 X | 12.8 X | 14 X | 15 X | 14.5 X |
| 3/25 | 6 X | 6 X | 6.0 X | 12 X | 14 X | 13.0 X | 17 X | 17 X | 17.0 X |
| 3/27 | 4 X | 4 X | 4.0 X | 16 X | 16 X | 16.0 X | 18 X | 18 X | 18.0 X |
| 4/1 | 6 X | 6 X | 6.0 X | 10 X | 11 X | 10.5 X | 14 X | 15 X | 14.5 X |
| 4/13 | 6 X | 6 X | 6.0 X | 14 X | 14 X | 14.0 X | 16 X | 16 X | 16.0 X |
| 4/15 | 6 X | 6 X | 6.0 X | 14 X | 14 X | 14.0 X | 16 X | 16 X | 16.0 X |
| 4/22 | 6 X | 6 X | 6.0 X | 12 X | 12 X | 12.0 X | 18 X | 16 X | 17.0 X |
| 4/24 | 6 X | 6 X | 6.0 X | 12 X | 13 X | 12.5 X | 18 X | 18 X | 18.0 X |
| 4/31 | 6 X | 6 X | 6.0 X | 16 X | 16 X | 16.0 X | 18 X | 18 X | 18.0 X |
| 5/4 | 6 X | 6 X | 6.0 X | 15 X | 15 X | 15.0 X | 16 X | 16 X | 16.0 X |
| 5/8 | 6 X | 6 X | 6.0 X | 16 X | 18 X | 17.0 X | 20 X | 19 X | 19.5 X |

NOTE: B.O.—Sufficient base-out prism added to create crossed diplopia, amount of base-out slowly reduced until patient reported the dissociated images were in vertical alignment.
B.I.—Sufficient base-in prism added to create uncrossed diplopia, amount of base-in slowly reduced until patient reported the dissociated images were in vertical alignment.

## RESULTS AND DISCUSSION

The ACA ratio by direct measurement was determined by the method of Morgan[2], "Immediately after the phoria for near fixation a second phoria through a plus 1.00 diopter sphere add is taken. The difference in the convergence thus measured gives the amount by which a unit change in accommodation affects convergence. For example, if the phoria through the subjective with fixation at 40 cm. is 3 diopters of exophoria and the phoria through a +1.00 D.S. add over the sub-

jective is 6 diopters of exophoria, then the ACA ratio is —3.00/+1.00 or simply 3/1. The advantages of this method are its extreme simplicity and the fact that psychic nearness convergence is eliminated since it probably is constant for both measurements and thus disappears in the subtraction. Its disadvantage is that the change is small and an error in measurement will represent a rather large proportion of the whole measurement."

The ACA ratio by calculation was determined by the method of Fry[7]:

$$\text{ACA Ratio} = \frac{15 - \text{No. 8} + \text{No. 13B}}{2.50}$$

Where, No. 8 = Phoria at Far (Tonic Convergence)
No. 13B = Phoria at Near (Fusional Convergence)

In using the above equation, exophoria is considered as a negative quantity and esophoria is considered as a positive quantity.

Table V is a tabulation of the ACA ratio as determined by each method for the twenty testing periods. These data are given for only eight of the subjects because of space limitation. The remaining subjects all exhibited the same typical random variation of the ACA ratio. Table VI presents a summary of the average and standard deviation of the ACA ratio obtained for each of the observers by each method. Also included in this table is the coefficient of variation (V). The coefficient of variation is a dimensionless measure of dispersion or spread of the data.[8] It is immediately evident from the data of Table VI that the coefficient of variation for the ACA ratio as determined by the method of Fry is one-half of the variation as found for the ACA ratio as determined by the method of Morgan. The determination of the ACA ratio by the method of Fry (calculation) does include psychic convergence as a factor. The direct measurement of the ACA ratio by the method of Morgan is of course free of this factor. It is of interest to note that the overall average ACA ratio by the method of calculation (Fry) is 4.7, while the overall average ACA ratio by the method of direct determination (Morgan) is 4.1. This small difference of 0.6 ACA ratio units, indicates the small amount of psychic convergence present for our experienced observers.

For our observers the ACA ratio as determined by direct measurement (Morgan) had a greater variability than the ACA ratio as determined by calculation (Fry). The question arises, "Do these variations in the day-to-day measurement of the ACA ratio vary in the same direction or in random order?" This was determined by calculating the coefficient of correlation (r) between the values obtained for

TABLE V

The Variation in ACA Ratio as Found Upon Successive Testing as Determined by Calculation (Fry) and by Direct Measurement (Morgan)

| Subject: | Miller | | Teitel | | Tashna | | Lux | |
|---|---|---|---|---|---|---|---|---|
| Date | X (Fry) | Y (Morgan) | X (Fry) | Y (Morgan) | X (Fry) | Y (Morgan) | X (Fry) | Y (Morgan) |
| 1 | 1.0 | 1.0 | 7.6 | 6.5 | 0.8 | 0.0 | 5.4 | 4.5 |
| 2 | 1.1 | 1.5 | 7.5 | 7.3 | 4.1 | 6.5 | 5.2 | 5.0 |
| 3 | 1.2 | 2.0 | 7.4 | 7.5 | 2.0 | 2.0 | 6.2 | 7.5 |
| 4 | 0.8 | 1.0 | 6.0 | 9.5 | 3.0 | 3.5 | 5.0 | 5.0 |
| 5 | 0.2 | —1.5 | 6.4 | 8.5 | 4.4 | 4.0 | 4.4 | 4.5 |
| 6 | 0.6 | 2.0 | 6.8 | 8.5 | 2.8 | 4.0 | 5.0 | 4.0 |
| 7 | 1.2 | 1.0 | 7.0 | 7.0 | 2.8 | 4.0 | 4.4 | 5.5 |
| 8 | 1.0 | 2.0 | 5.2 | 6.0 | 2.8 | 2.0 | 4.8 | 3.5 |
| 9 | 1.8 | 1.0 | 6.0 | 5.5 | 3.2 | 4.0 | 5.6 | 5.0 |
| 10 | 6.4 | 5.0 | 6.8 | 8.5 | 3.3 | 1.7 | 5.0 | 5.5 |
| 11 | 1.8 | 1.5 | 7.4 | 6.5 | 3.2 | 4.0 | 4.0 | 3.5 |
| 12 | 1.0 | 2.0 | 6.6 | 9.5 | 1.2 | 2.0 | 4.4 | 4.0 |
| 13 | 1.4 | 3.0 | 8.2 | 9.5 | 4.2 | 4.0 | 4.6 | 3.5 |
| 14 | 2.0 | 1.3 | 6.8 | 6.0 | 2.8 | 2.0 | 4.4 | 4.0 |
| 15 | 1.4 | 2.5 | 5.8 | 3.0 | 2.8 | 1.5 | 4.4 | 3.0 |
| 16 | 0.8 | 2.0 | 6.0 | 5.5 | 3.6 | 5.0 | 4.8 | 4.5 |
| 17 | 1.8 | 2.0 | 4.8 | 5.5 | 3.4 | 5.5 | 3.4 | 0.0 |
| 18 | 0.6 | 0.5 | 5.0 | 6.0 | 2.0 | 2.0 | 4.2 | 3.0 |
| 19 | 1.4 | 1.5 | 5.2 | 4.5 | 2.4 | 1.0 | 4.4 | 2.5 |
| 20 | 2.8 | 1.5 | 6.2 | 6.0 | 1.6 | 2.5 | 4.8 | 2.5 |

| Subject: | Rosen | | Gould | | Shane | | Stein | |
|---|---|---|---|---|---|---|---|---|
| 1 | 4.4 | 5.0 | 6.7 | 6.8 | 3.8 | 3.5 | 1.7 | 1.8 |
| 2 | 4.0 | 3.0 | 5.8 | 5.5 | 4.3 | 5.8 | 2.0 | 1.5 |
| 3 | 4.0 | 3.5 | 6.0 | 8.0 | 3.8 | 3.0 | 3.0 | 2.3 |
| 4 | 4.4 | 3.5 | 6.7 | 4.3 | 4.9 | 5.5 | 2.8 | 3.8 |
| 5 | 4.0 | 5.0 | 5.8 | 4.5 | 3.7 | 5.3 | 2.8 | 2.8 |
| 6 | 4.2 | 5.5 | 6.0 | 4.5 | 3.8 | 3.5 | 3.3 | 2.5 |
| 7 | 4.2 | 5.5 | 7.2 | 6.0 | 3.3 | 3.0 | 3.2 | 2.0 |
| 8 | 5.4 | 6.5 | 6.2 | 5.0 | 2.8 | 3.0 | 3.9 | 4.5 |
| 9 | 3.7 | 3.0 | 5.8 | 3.0 | 4.3 | 7.3 | 2.8 | 4.5 |
| 10 | 3.4 | 3.0 | 6.0 | 5.5 | 3.8 | 4.5 | 2.7 | 0.8 |
| 11 | 4.2 | 5.0 | 5.4 | 5.0 | 5.8 | 8.0 | 3.5 | 1.8 |
| 12 | 4.4 | 4.0 | 4.9 | 4.7 | 4.6 | 6.5 | 2.2 | 1.0 |
| 13 | 4.0 | 2.0 | 5.4 | 3.5 | 4.6 | 6.0 | 2.4 | 2.0 |
| 14 | 4.0 | 3.5 | 7.4 | 4.0 | 5.0 | 5.5 | 3.2 | 0.8 |
| 15 | 5.0 | 5.5 | 6.0 | 5.5 | 3.6 | 2.5 | 1.7 | 2.0 |
| 16 | 5.4 | 7.3 | 5.4 | —0.5 | 3.8 | 3.0 | 2.5 | 1.0 |
| 17 | 4.4 | 5.5 | 5.5 | 2.8 | 4.6 | 6.0 | 4.2 | 1.0 |
| 18 | 4.4 | 6.5 | 6.6 | 5.0 | 3.9 | 4.8 | 2.4 | 0.8 |
| 19 | 3.4 | 5.0 | 6.2 | 3.0 | 5.0 | 8.0 | 2.8 | 1.8 |
| 20 | 4.0 | 4.5 | 6.6 | 4.0 | 4.6 | 6.5 | 2.0 | 0.0 |

NOTE: The above data are typical of the 22 members of the Gamma Omega Phi Fraternity of Northern Illinois College of Optometry who participated in this investigation.

the ACA ratio by each of the methods for our individual observers. The results have been recorded in Table VII. Inspection of Table VII

TABLE VI

A Comparison of the Mean Value and the Variability of the ACA Ratio as Determined by Calculation (Fry) and by Direct Measurement (Morgan)

| Subject | ACA Ratio (Fry) Mean | Std. Dev. | V | ACA Ratio (Morgan) Mean | Std. Dev. | V |
|---|---|---|---|---|---|---|
| Rosen | 4.2 | 0.52 | 12.5 | 4.6 | 1.36 | 29.6 |
| Gould | 6.1 | 0.62 | 10.2 | 4.5 | 1.65 | 36.6 |
| Shane | 4.2 | 0.68 | 16.2 | 5.1 | 1.70 | 33.4 |
| Stein | 2.8 | 0.66 | 23.6 | 1.9 | 1.19 | 63.0 |
| Wasserman | 5.8 | 1.18 | 20.4 | 4.7 | 3.28 | 69.8 |
| Weisman | 3.9 | 0.93 | 23.8 | 4.7 | 1.71 | 36.3 |
| Silverstein | 7.1 | 0.59 | 8.3 | 6.9 | 1.18 | 17.1 |
| Parker | 3.5 | 0.79 | 22.5 | 3.1 | 1.16 | 37.4 |
| Liberson | 3.9 | 0.95 | 24.4 | 4.8 | 2.18 | 45.4 |
| Pitasch | 4.8 | 0.48 | 10.0 | 4.1 | 1.16 | 28.3 |
| Greenfield | 4.8 | 0.81 | 16.8 | 5.7 | 1.31 | 23.0 |
| Reyhan | 3.8 | 0.40 | 10.5 | 2.1 | 0.88 | 42.0 |
| Stern | 3.2 | 0.65 | 20.4 | 3.0 | 1.30 | 43.3 |
| Hartstein | 5.4 | 0.80 | 14.8 | 4.7 | 2.36 | 50.2 |
| Signer | 6.8 | 0.74 | 10.9 | 2.8 | 2.33 | 83.2 |
| Eichler | 4.9 | 0.89 | 18.2 | 4.6 | 1.78 | 38.7 |
| Pollack | 5.0 | 0.63 | 12.6 | 3.5 | 1.99 | 56.9 |
| Friedman | 7.0 | 1.20 | 17.2 | 4.7 | 2.16 | 46.0 |
| Miller | 1.5 | 1.26 | 84.0 | 1.6 | 1.18 | 73.5 |
| Teitel | 6.5 | 0.93 | 14.3 | 6.9 | 1.72 | 25.0 |
| Tashna | 2.8 | 0.93 | 33.2 | 3.1 | 1.58 | 51.0 |
| Lux | 4.7 | 0.59 | 12.5 | 4.0 | 1.48 | 37.0 |
| Average | 4.7 | 0.78 | 19.9 | 4.1 | 1.66 | 43.9 |

NOTE: $V = \frac{100 \text{ (Std. Dev.)}}{\text{Mean}}$ V, Coefficient of Variation

reveals a variation in the amount of the correlation from a low of 0.02 to a high of 0.87 (where 0.537 is necessary to be significant at the 1% level). Closer inspection of our data reveals that those observers who have a greater difference in the ACA ratio as determined by calculation (Fry) and by direct measurement (Morgan) possess a smaller coefficient of correlation between these two methods of measuring the ACA ratio. Since this difference between the two methods of measuring the ACA ratio is attributed to psychic convergence, we can state that when the amount of psychic convergence is high that the resulting coefficient of correlation between these two methods of calculating the ACA ratio will be low. It is possible that the amount of psychic convergence varies to a greater degree than other components which affect the convergence mechanism and therefore those observers who have appreciable amounts of this factor will have a lower coefficient of correlation between the ACA ratio as determined by each of these methods.

TABLE VII

The Linear Correlation Between ACA Ratio as Determined by Calculation (Fry) and by Direct Measurement (Morgan)

| Subject | r | Subject | r |
|---|---|---|---|
| Stern | 0.87 | Tashna | 0.60 |
| Liberson | 0.82 | Teitel | 0.52 |
| Shane | 0.82 | S'lverstein | 0.52 |
| Lux | 0.79 | Signer | 0.48 |
| Greenfield | 0.73 | Parker | 0.32 |
| Weisman | 0.72 | Stein | 0.30 |
| Miller | 0.71 | Pollack | 0.29 |
| Pitasch | 0.69 | Gould | 0.28 |
| Rosen | 0.68 | Reyhan | 0.22 |
| Hartstein | 0.64 | Friedman | 0.09 |
| Eichler | 0.63 | Wasserman | 0.02 |

NOTE: r = 0.423 significant at the 5% level
r = 0.537 significant at the 1% level

We have found that the variation of the ACA ratio is at a minimum when obtained by the method of calculation (Fry). In computing the ACA ratio by this method we use the following formula:

$$\text{ACA Ratio} = \frac{15 - \text{No. 8} + \text{No. 13B}}{2.50} \qquad (1)$$

$$\text{or, ACA Ratio} = \frac{15}{2.5} - \frac{(\text{No. 8} - \text{No. 13B})}{2.5} \qquad (2)$$

$$\text{ACA Ratio} = C_1 - \frac{(\text{No. 8} - \text{No. 13B})}{C_2} \qquad (2)$$

From equation (3) we have: the ACA ratio is directly proportional to the difference between the phoria at far and the phoria at near (No. 8—No. 13B). We now have a comparative unit for the study of the variability of the ACA ratio and the phoria tests, since the ACA ratio is directly proportional to the difference between these tests. The best measure of dispersion or variability of test data is the standard deviation. In Table VIII we have a tabulation of the standard deviation for the phoria at far (No. 8), the phoria at near (No. 13B) and the difference between these two phoria tests (No. 8—No. 13B). The average standard deviations for these tests are 1.12, 1.97 and 1.97 respectively. The variation or standard deviation of the difference between the two phoria tests is of the same order of magnitude as the phoria tests themselves. It is thus obvious that the variation of the ACA ratio is of the same magnitude as the phoria at far (No. 8) and the phoria at near (No. 13B). Since it has never been considered that these phoria tests are a constant, we must conclude on the basis

of the present data that the ACA ratio is not a constant but is a variable which fluctuates in amount equivalent to the variation in the phoria tests. This is particularly true of the near phoria test since it contributes a greater quantity to the calculation of the ACA ratio. This same observation was made by Fry and Haines[7] who state, "Furthermore, the phorias at near have a wider distribution, the standard error being ± 2.1 diopters at distance and ± 4.1 diopters at near. This means that variations in the ACA ratio are made possible primarily by variations in the phorias at near."

TABLE VIII

A Comparison of the Variation Found for the Phoria Test at Far (No. 8), the Phoria Test at Near (No. 13B) and the Difference Between These Phoria Tests

| Subject | No. 8 Std. Dev. | No. 13B Std. Dev. | (No. 8 - No. 13B)* Std. Dev. |
|---|---|---|---|
| | | (No. 8 - No. 13B) | |
| Rosen | 1.00 | 1.37 | 1.30 |
| Gould | 1.00 | 2.00 | 1.55 |
| Shane | 0.78 | 1.38 | 1.70 |
| Stein | 0.99 | 1.63 | 1.73 |
| Wasserman | 1.23 | 2.42 | 2.96 |
| Weisman | 0.88 | 2.63 | 2.32 |
| Silverstein | 0.78 | 1.73 | 1.77 |
| Parker | 1.73 | 1.81 | 1.96 |
| Liberson | 0.69 | 2.58 | 2.36 |
| Pitasch | 0.93 | 1.63 | 1.15 |
| Greenfield | 0.96 | 2.05 | 1.91 |
| Reyhan | 0.49 | 0.69 | 1.00 |
| Stern | 0.85 | 1.50 | 1.62 |
| Hartstein | 0.89 | 1.90 | 1.98 |
| Signer | 1.38 | 1.98 | 2.20 |
| Eichler | 0.79 | 2.41 | 2.13 |
| Pollack | 2.92 | 3.71 | 1.52 |
| Friedman | 0.52 | 2.60 | 3.01 |
| Miller | 2.30 | 1.66 | 3.11 |
| Teitel | 2.16 | 1.98 | 2.33 |
| Tashna | 0.50 | 2.13 | 2.25 |
| Lux | 0.82 | 1.58 | 1.45 |
| Average | 1.12 | 1.97 | 1.97 |

*Exophoria is considered as a minus quantity; Esophoria as a plus quantity.

SUMMARY

1. The ACA ratio as obtained by calculation (Fry) had less dispersion or variation than the ACA ratio obtained by direct measurement (Morgan).

2. The standard deviation of the ACA ratio obtained in this study agrees in magnitude with other studies.

3. The ACA ratio as determined by the method of calculation (Fry) is directly proportional to the difference between the phoria at far and at near (No. 8 — No. 13B). Our results show that the varia-

tion or dispersion of the individual phoria tests is of the same order of magnitude as the difference between the phorias, thus they are respectively 1.12, 1.97 and 1.97.

4. Since the ACA ratio is directly proportional to the difference between the phorias, we must conclude that the variation of the ACA ratio is of the same order of magnitude as this difference between the phoria tests. Since these phoria tests are not considered as unique physiological constants, it becomes obvious that the ACA ratio cannot be a constant.

5. We must conclude therefore that the ACA ratio is a psychophysiological variable that will fluctuate in amount depending upon the exigencies of the day and the demands of the environment. These variations will be in amount about the same as the fluctuation in the phorias at far and at near.*

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*EDITORIAL FOOTNOTE TO MANAS AND SHULMAN PAPER

Certain editorial comments seem to be in order to clarify a terminological difference between the present authors and former authors in the use of the phrase "constant function."

Biologically, a constant function is one which does not change in a systematic fashion. In this sense, the blood pressure of an individual is usually considered to be a constant measure, even though it varies within a limited range from time to time. On the other hand, the height of a growing child, increasing from year to year, is regarded as a variable measure. All measurements, physical, biological, and psychophysical are characterized by variations, sometimes spoken of as errors of measurement.

By way of example, if the length of a room were measured with a millimeter scale, ten successive measurements would undoubtedly yield as many different readings. Yet, we do not question that the length of the room is constant. Nor yet do we conclude that the room expands and contracts due to the "exigencies of the day." Former authors, using the term *constant* in a biological sense, have maintained that the ACA ratio does not vary with age, with accommodative level, nor with extended visual training. The present authors have not necessarily altered this concept. Rather, using a literal definition of a constant function, they have demonstrated that the ACA ratio varies from day to day. Whether this variation is consequent upon errors of measurement or other factors cannot be determined from the data.

This footnote does not, however, detract from the inherent usefulness of the

data presented. The authors have contributed to optometric science in that the data serve to reaffirm the concept of variability of all measurements. The particular value of these data is that they will serve as a yardstick for future studies. The data incorporated in this paper show what variation occurs *without* changes in age or visual training. Other studies attempting to demonstrate that the ACA ratio has been changed by some means (visual training, for example) will have to demonstrate a change greater than that found by the present authors. It is for this reason that the data are so valuable to optometric science, and it is for this reason that the editors, although in disagreement with certain of the conclusions, have chosen to present this valuable paper to the profession.

MONROE J. HIRSCH.

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## AMERICAN ACADEMY OF OPTOMETRY

### ELECTED TO FELLOWSHIP

The following optometrists and educators have been elected to Fellowship in the American Academy of Optometry. The Academy welcomes these new members.

Mr. William Ellis Brown, 18 Russell Road, Rhyl, North Wales, England.

Mr. Wilfred G. B. Colls, 22 Oxford St., Newcastle-on-Tyne, Northumberland, England.

Dr. Margaret S. Dowaliby, Los Angeles College of Optometry, 950 W. Jefferson Blvd., Los Angeles, California.

Mr. R. L. Freeman, 7 Church St., Liverpool, England.

Mr. John Calder Gillie, 4 Northumberland Place, North Shields, England.

Dr. Phillip R. Haynes, 114 North 21st St., Newark, Ohio.

Lt. Comdr. Paul R. Kent, MSC, USN., U. S. Naval Hospital, Bremerton, Washington.

Dr. Coleman G. Lecker, R. O., 183 Charlotte St., Sydney, Nova Scotia, Canada.

Dr. Hugh D. MacKensie, R. O., 513-514 McCallum Hill Bldg., Regina, Saskatchewan, Canada.

Dr. Robert I. McQuarrie, R. O., 620 Third St., Medicine Hat, Alberta, Canada.

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Dr. James G. Rowand, R. O., 707 Tegler Bldg., Edmonton, Alberta, Canada.

Dr. Earl R. Smith, 105 W. Wall St., Morrison, Illinois.

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# CINERAMA, CINEMASCOPE AND 3-D*

## A DISCUSSION OF ADVANTAGES AND LIMITATIONS

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Rochester, New York

This paper is a brief description of new screen techniques which have changed profoundly the outlook for the motion picture world. The year 1953 approximates the beginning of the second half century of motion picture entertainment. Stereoscopic motion pictures, the wide screen techniques of which Cinerama and CinemaScope are the most publicized and the additional ingredient of stereophonic sound may well provide new challenges for Hollywood's productiveness and technical skill. They also provide a new challenge to exhibitors, who face the responsibility of modifying or replacing their theatres and equipment. They are revolutionary changes which offer new opportunities for the motion picture industry.

These newly available forms of entertainment, wide screen and stereo, are manifest examples of the changing visual demands of our civilization. They emphasize the growing importance of skillful binocular vision in our everyday occupations. Because of the implications to the eyecare professions and the entire ophthalmic field, we shall describe each system briefly in the hope that it will help to create public awareness of the increasing importance of skillful binocular vision in our productive, as well as our entertainment occupations. First, however, let us look at what happened to create this favorable situation.

Some of the testimonials which came from what Lowell Thomas calls, "A new adventure in sight and sound," are:

"Gives one the startling sensation of being spang in the middle of the screen."[1]

"Most spectacular and thrilling. Produces sensations that are arousing, intoxicating—and unique."[1]

"What a thrilling experience, and my husband said he felt he could reach right out and shake hands with Lowell Thomas."[1]

"The two most exciting things I have ever seen in New York are Cinerama and the United Nations Building."[1]

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*Read before the annual meeting of the American Academy of Optometry, Chicago, Illinois, December 6, 1953. For publication in the August, 1954, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

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Fig. 1. Opening Roller Coaster scene of "This Is Cinerama" as seen through the eye of an artist. In this installation the three projectors are located above the auditorium floor and are built out from the mezzanine. (Courtesy of Quigley Publishing Co.)

"A captivating experience—brings the world right across the screen."[1]

"Obviously you have a great thing here which should do for movies what nylon has done for stockings—not only reformed them but bettered them."[1]

And so run the testimonials of some of the famous people who have seen "This is Cinerama."

On October 1, 1952, the sleeping giant of the motion picture industry suddenly awakened from a frustrating inaction which had kept it in a state of depression for the past several years. This awakening followed the opening of Cinerama in New York City. It was a spectacular, history-making production which profoundly influenced those who were fortunate enough to see it. It was nothing new because it had been rejected by the motion picture companies years ago. It was noteworthy in that persons from outside the industry had created it. They had raised the money, produced the films, remodeled a theatre and had given a convincing demonstration of its workability and its powerful appeal to the public. It shook the producers and exhibitors out of their lethargy and unlocked the door to vast possibilities for a new approach in the production and exhibition of films.

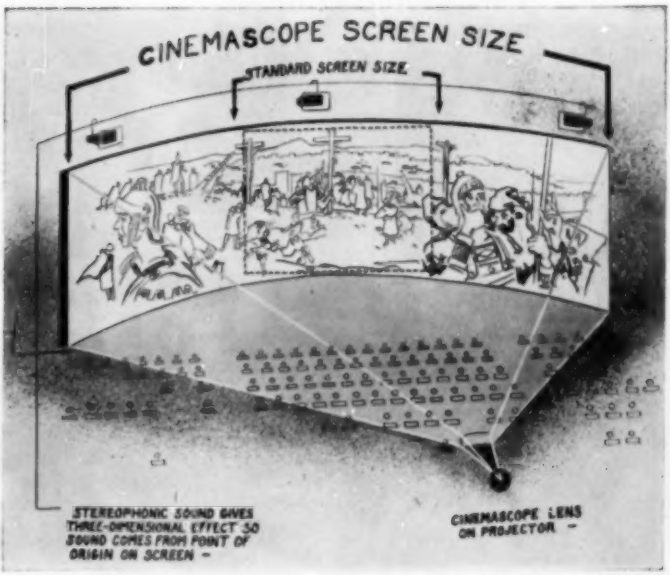
CINEMASCOPE SCREEN SIZE
STANDARD SCREEN SIZE
STEREOPHONIC SOUND GIVES THREE-DIMENSIONAL EFFECT SO SOUND COMES FROM POINT OF ORIGIN ON SCREEN –
CINEMASCOPE LENS ON PROJECTOR –

Fig. 2. Sketch by George Davis showing the dimensional proportions of a scene from "The Robe."

The impact of Cinerama stimulated an immediate, rushing search for other previously rejected techniques to match the unprecedented public appeal which Cinerama had demonstrated. The pioneers of stereo motion pictures who had for so many years been trying to get recognition in Hollywood, were now in a favorable position to crash the barriers which had kept them from putting 3-D into major production.

Then came Bwana-Devil, a stereo film produced on a very limited budget by Arch Oboler and his associates, two of whom were Milton Gunzburg, the writer, and his ophthalmologist brother, Julian. Even though the exceedingly modest capital did not permit what might be considered adequate preparation for production and for equipping and training of exhibitors, the public response to this 3-D film was positive and immediate. It proved to be a financial success far exceeding the expectations of those who risked their money and time to back it.

A different road was taken by 20th Century Fox. They sought out the inventor of the anamorphic lens system, Prof. Henri Chretien of France, and began developing it for their panoramic process which they call CinemaScope.

Fig. 3. (Left) 35 mm. film image recorded with Baltar taking lens alone. (Right) 35 mm. film image as recorded with the Baltar and CinemaScope taking lenses.

Fig. 4. The same scene as in Figure 3 (Right), from "The Robe" as it appears when the compressed film image is re-formed to full proportions on the CinemaScope screen through the special projection lens.

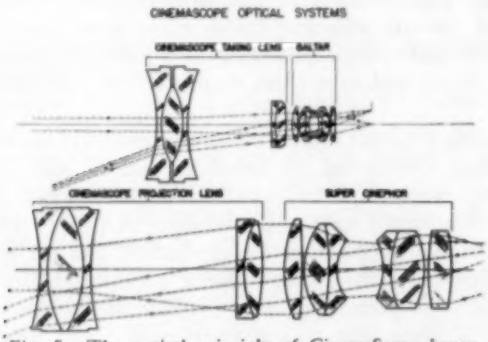


Fig. 5. The optical principle of CinemaScope lenses.

The motion picture industry including their suppliers of sound equipment, lighting equipment, lenses, cameras, projectors, screens, polarizing accessories and many other items responded promptly to the

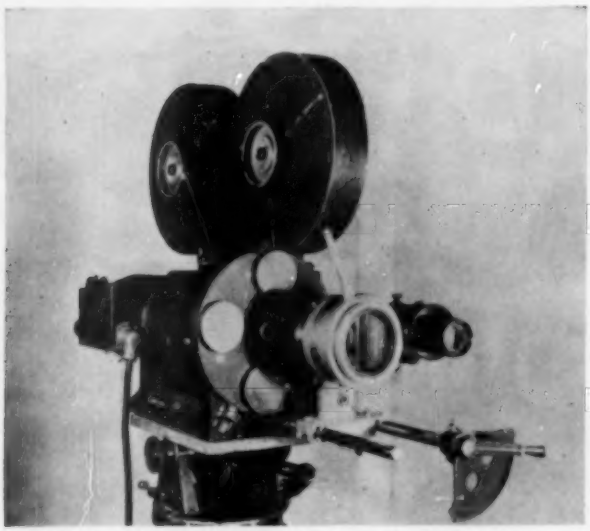

Fig. 6. Camera equipped with CinemaScope taking lens.

challenging opportunity of this sudden revolution in production and exhibition. They stepped up their schedules and applied their imagination, their art, their technical ability and resourcefulness in a most effective way.

We shall attempt to outline briefly the what, the why and the how of each system.

CINERAMA

Cinerama which did so much to awaken the motion picture industry into new action is the brain child of Fred Waller, who is best known for his technical contributions to motion pictures.[2] During the War he developed the Waller Flexible Gunnery Trainer for the Air Corps.[3] This equipment provided realistic and effective training for thousands of gunners in the Air Force during World War II. Five synchronized projectors threw a mosaic moving picture of combat planes onto a huge curved screen from standard 35mm. films. The electronically recording practice guns of the trainees indicated the number of hits scored by each trainee.

This Waller creation demonstrated the feasibility of the multiple projector panoramic mosaic process. Cinerama adopted this principle but it uses only three projectors as shown by the artist in Figure 1.

The huge curved screen is composed of narrow vertical strips

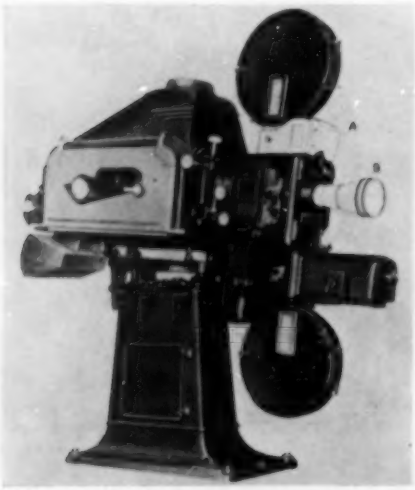

Fig. 7. Projector equipped with CinemaScope projecting lens, (B), and Magnetic sound attachment (A).

similar in structure to slats of a vertical venetian blind. Each of the three carefully synchronized projectors of 35mm. film throws its own third of the complete picture onto its own area of the screen while a fourth one handles the optical sound tracks. The result is three laterally contiguous pictures forming a huge panoramic scene full of color and motion with its dramatic effects reinforced and enhanced by stereophonic sound.

Cinerama is particularly effective in portraying vast, spectacular scenes. It gives a so-called eyeful of sight, and an earful of sound.

There are many engineering problems connected with Cinerama which do not appear to the average customer. Some of these problems are:

1. The perfect synchronization of the three pictures.
2. Control of the illumination so that all three pictures will have equal luminosity.
3. Matching of the pictures so that overlap or distortion where the contiguous areas join will be minimized.

Most of the limitations of Cinerama are economic and architectural such as (a) the cost of remodeling theatres, (b) the apparent long run that each new Cinerama film must have in order to produce a profit. Some estimators state that only 50 large city theatres in the United States can accommodate and support Cinerama. Optimistic surveys

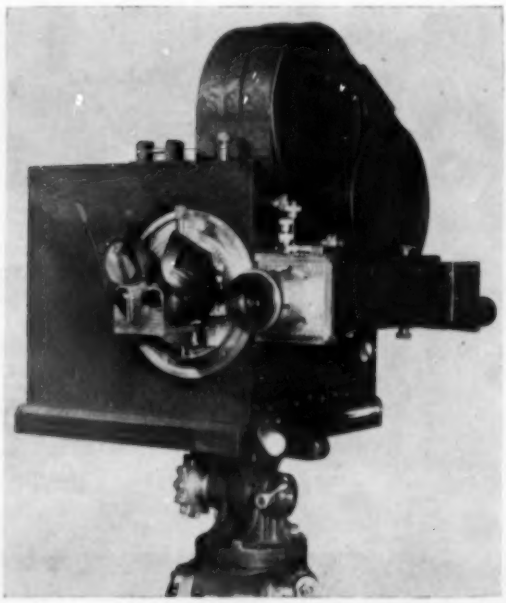

Fig. 8. The Front view of the Norling Camera reveals the V shaped variable inter-axial control. At the base of the V is a micrometer head which can be adjusted easily to control convergence. The view finder to the right of the V enables the cameraman to follow the scene as it is being photographed.

suggest that three times this number can be profitably converted. At this time it would seem that this medium must be limited to urban centers sufficiently large to support long runs. However, when Cinerama productions become more numerous, smaller cities probably can supply the customers for more frequently changed features.

CINEMASCOPE

CinemaScope is the 20th Century-Fox answer to Cinerama.[4] It might be referred to as the Ford Car Cinerama. Using 35mm. film, it places a panoramic picture on a screen that is approximately two and one-half times as wide as it is high. To be more exact, the ratio is 2.55 to 1 in contrast to the conventional ratio of 1.33 to 1. Figure 2 shows relative proportions.

CinemaScope uses a process developed by Professor Henri Chretien of France, and modified by 20th Century-Fox, and their supplier of anamorphic lenses, the Bausch & Lomb Optical Company, to make it more applicable to studio use.

The components of the CinemaScope process are:

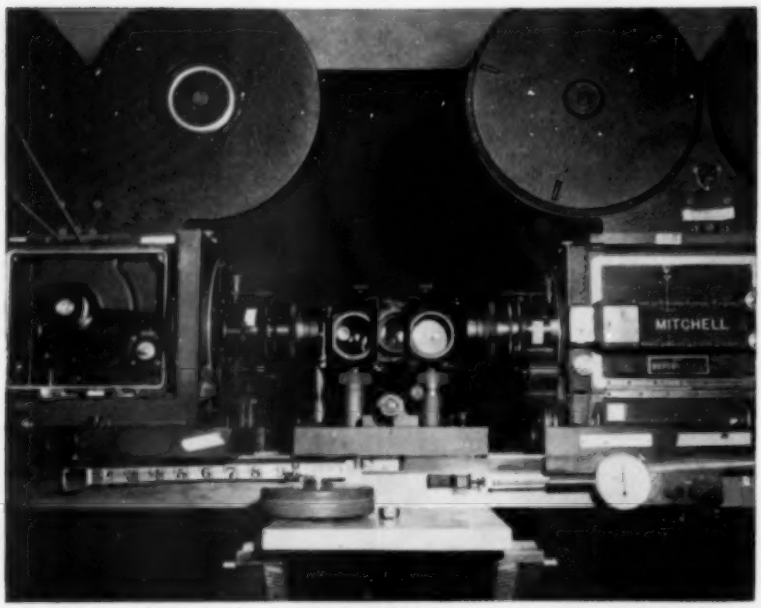


Fig. 9. The Natural Vision Camera comprises two synchronized Mitchell 35 mm. cameras mounted opposed. Images are brought to the lens systems from twin variable mirrors.

(1) A special anamorphic lens attachment for a standard 35mm. motion picture camera. This lens, through its cylindrical components, compresses the picture laterally without distorting it vertically, thereby reproducing a wide horizontal area on the film while maintaining the standard height of the picture.

(2) A special anamorphic lens placed in front of a standard 35mm. projector. This lens reforms the compressed, distorted image of the film and spreads it onto the screen in the true proportion of the actual scene which was photographed.

(3) A special CinemaScope screen.

(4) A specially made 35mm. color film with sprocket perforations reduced in size to make room for the four magnetic sound tracks.

(5) A special magnetic sound attachment for the projector. (See Figure 7.)

(6) Increased illumination to cover the larger area of the screen.

ADVANTAGES OF CINEMASCOPE

CinemaScope provides a vast panoramic picture with stereophonic

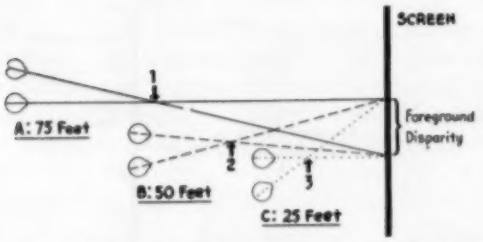


Fig. 10. Foreground or crossed disparity. Arrows 1, 2 and 3 show the location of the image for three individuals sitting at 25, 50 and 75 feet from the screen.

sound with the use of but one projector, and standard width 35mm. film. Some critics say that it approaches Cinerama in its ability to portray spectacular shots, but that it can not equal it. However, thousands of theatres which cannot easily be adapted for Cinerama can be equipped with CinemaScope and the reconversion can be done at a fraction of the cost.

OTHER WIDE SCREEN PROCESSES

Cinerama and CinemaScope are known to the trade as panoramic or wide screens. Another wide screen process consists of using regular projectors with short focal length lenses to spread the picture from a 35mm. film over a much larger area. The top and bottom half of the picture are cropped or masked out with the result that the picture covers a screen with a ratio as high as 1.85 to 1. This process gives bigger pictures than conventional past processes but it does not encompass as much of the scene as does Cinerama or CinemaScope.

STEREOSCOPIC MOTION PICTURES

The term 3-D has been applied loosely to cover all of the newer forms of motion pictures including Cinerama, CinemaScope, and other wide screen techniques, as well as true stereoscopic motion pictures. We shall use the term 3-D only as it applies to the stereoscopic process.

Some of the ingredients of stereoscopic motion pictures are:

1. A synchronized, dual motion picture camera containing a right eye and a left eye optical system.

2. Conventional optical sound tracks either for stereophonic or regular sound on one or both films.

3. A metallized non-depolarizing screen with a high light reflectivity such as that developed for Cinema-Scope or other wide screen techniques.

4. Two projectors, one for the right eye film and one for the left eye film, and linked together mechanically or electrically. These

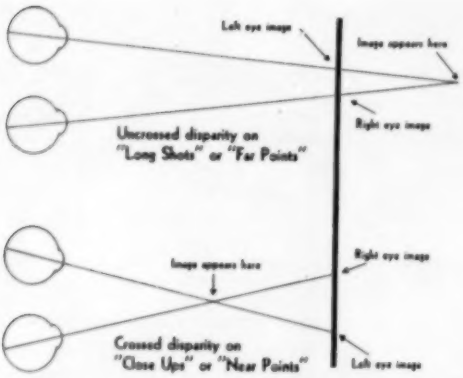


Fig. 11. Crossed and uncrossed disparity.

projectors must be synchronized precisely and have lenses matched as closely as is practical.[6]

5. Polarizing filters in each of the two projectors.

6. Polarizing spectacles (for each member of the audience) which will filter the projected polarized right eye and left eye pictures on the screen so that the right eye sees only the right eye projected image and the left eye sees only the left eye projected image.

TYPES OF STEREO CAMERAS

Considerable confusion exists concerning the most desirable type of stereo camera. The Norling Stereoscopic Camera is illustrated in Figure 8. The interaxial distance can be adjusted from 1½" to 4".[7]

Figure 9 illustrates the Natural Vision camera which was used in the production of Bwana-Devil. The main differences between the several schools of thought concern the interaxial adjustment as it is varied from one shooting distance to another and the actual converging of the camera lenses or the optical system as the scene shifts from a long shot to a close-up.[8, 13, 11, 14]

Three-D when properly produced and projected is a highly personalized spectacular stereoscopic scene. The screen is barely more than a reference point. The mental images of actors and the set or the scene are out in front of the viewer in space, directly in the line of sight, as the cameras saw them in the shooting of the scene. This is true whether one sits at the side, in the center, the front or in the back[9] of the theatre.

The disparity between right and left eye images is photographed onto the film by the stereocamera and in turn is thrown onto the screen by the projectors. The images which were far away from the camera

and which require relaxation of convergence (uncrossed disparity) for stereo seeing will appear to be behind the plane of the screen. On the other hand, the right and left eye images which require crossed visual axes (crossed disparity) will appear to be in front of the screen at the point where the visual axes cross. Figures 10 and 11 illustrate crossed and uncrossed disparity, and the localizing of the image at the point where the visual axes cross.[9]

PROBLEMS OF 3-D

Realistic and spectacular effects combined with personal participation are achieved by this medium. However, several problems have plagued 3-D. They can largely be classed as growing pains. The scramble for stereo pictures was precipiated almost overnight. Some of the makeshift steps which were taken were:

1. Two cameras were hastily linked together so that stereo production could get under way.

2. A few exhibitors linked two projectors together without sufficient thought of precise synchronization and framing, matching the projection lenses, providing adequate and matched illumination in the two projectors, or providing a suitable screen. Some, hastily bought aluminum paint to cover the surface of their mat or beaded screens. Some of the results were poor in that much of the light was depolarized and lost.

3. The producers of polarizing materials were caught short and did not have time to adequately develop comfortable viewing spectacles.

In spite of all this, nearly 100,000,000 pair of the polarizing viewers were purchased and used within a few months' time.

The unpreparedness of the motion picture industry and its suppliers in rushing stereo films out to the trade without orderly and effective training, and adequate reconversion, caused difficulties for some of the customers who spent their money to see 3-D movies. Nevertheless, th acceptance of the *process* has been good. Three-D is now pausing to consolidate its gains, and to prepare more adequately for production and exhibition.

Cinerama, CinemaScope, and other forms of wide screen and Stereo, all have engineering improvements under way. Many of the most competent and skilled engineers and technical men are hard at work on them. Some of them are planning to combine CinemaScope and other panoramic processes with Stereo.

VISUAL PROBLEMS

Each of the processes presents visual problems for some customers. The seats at the sides of the theatre are not considered good by many.

Some are visually more comfortable sitting close to the screen, others prefer to sit toward the back. A peripheral flicker in CinemaScope and Cinerama bothers some individuals. Symptoms of some visual difficulties are brought to light through resulting discomfort.

Three-D, more than 2-D, performs a public service for which it often is censored instead of receiving its due praise. It brings to light and amplifies symptoms of inefficient binocular functions. Those who lack desirable binocular poise may not be aware of these conditions. They may make compensations for them in performing every-day activities, or may have symptoms and not relate them to their vision. But when such persons attend a 3-D movie the impelling stimulus to binocular participation often cannot be ignored with the result that some form of discomfort may become evident. They may blame the difficulty on the polarizing spectacles, the picture, the process, or if their introspection is good, they may call on an ophthalmic practitioner for an eye examination and an analysis of seeing habits. 3-D pictures, (and panoramic pictures to a lesser degree) can bring real benefits to the public through stimulating interest in and action on binocular performance. This is an area where the ophthalmic professions have an opportunity to extend their services to the public. It is a plus value. It adds to the superb entertainment and education this medium can provide.[9]

Stereo motion pictures are different from other forms of stereo in some respects. A properly made stereoscopic picture viewed in a properly made Brewster type stereoscope mentally can reproduce life-size, true proportion, perspective, distance and color providing the viewing stereoscope and the taking camera are of the same focal length and providing the interaxial of the camera approximates the interpupillary distance of the subject.[10]

Projected stereo pictures, both still and motion, mentally can reproduce life size, proportion, perspective, distance and color, providing the projected picture is of the same visual angle as the subject would experience if he were seeing the actual scene from the position of the camera when the scene was photographed and providing the inter-ocular of the camera lenses approximates the interpupillary distance of the subject.

With non-moving, hand-viewed or projected stereo pictures certain specific limitations are desirable in order to avoid distortion, confusion, visual discomfort or doubling of images and the challenging of basic artistic concepts.[7] In stereo motion pictures with effective sound, the same limitations apply in general, but some of the areas of tolerance can be greater. The rapidly changing points of fixation, the reinforcing stimuli of motion, sound and drama modify samewhat the specific

restrictions of crossed disparity and of the stereo window which are so desirable in still pictures. The experimental results of Hill and his co-workers, and many others, are most interesting and encouraging.[11]

Many have asked the question about which of these systems will eventually win. The conviction of many authorities is that all of them, including conventional 2-D will be with us for a long time and that the winners will be the Motion Picture Industry and the public. According to Norling, "We may look forward to wide screen 3-D, as an early embellishment of the art and to the eventual wedding of bi-aural sound with wide screen 3-D, a wedding whose consummation would undoubtedly result in a most pleasant sound, the clinking of the coins in the box office."[12]

In conclusion may I offer my own opinion. Out of this continuing search for better motion picture entertainment will come patterns which will provide us with dynamic stereo effects free from objectionable distortions and free from discomfort inducing errors in projection and in production. It is not now within the range of possibility for full length stereo motion pictures to be viewed with complete visual comfort by those who lack adequate binocular poise and performance. For some persons the viewing of the stereo feature will help develop the desirable new skills but patients with anisometropia, vertical imbalances and similar anomalies have problems for ophthalmic science and practice to solve rather than for the engineers of the motion picture industry.

Years ago some in the motion picture industry honestly objected to "talkies." They reasoned that persons who had hearing deficiencies would be eliminated as customers. This same reasoning should not apply to wide screen and 3-D, because something can be done to bring binocular vision up to a desirable level of performance in a very high percentage of people.

When the industry and the ophthalmic professions recognize this plus value as an opportunity for public service, the cause of better vision and general well being of the public will be greatly enhanced.[9]

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## BOOK REVIEW

CLINICAL MANUAL ON ANISEIKONIA. Robert E. Bannon. Published by the Instrument Division, American Optical Company, Buffalo 15, New York. 119 pages. 41 illustrations. Board covers. $1.00. 1954.

This small volume, which is a compilation of lectures by the author, is essentially what it claims to be,—"a clinical manual." Discussion of the theoretical and philosophical aspects of aniseikonia have been avoided and emphasis has been placed on those phases of the subject necessary to make the optometrist familiar with the condition and its correction.

Every optometrist, whether he intends to become an aniseikonic clinician or not, should be able to discuss the problem. This manual is the most direct route to more than a passing acquaintance with this new branch of science in optometry. Because aniseikonia is inseparable from applied optics and optometry, no optometrist can afford to ignore this newest field of clinical practice.

The new manual is most useful and contains an excellent and complete bibliography.

G. M. BELANGER

# A SECOND REPORT ON THE FITTING AND USE OF MICROLENSES*

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Pennsylvania State College of Optometry
Philadelphia, Pennsylvania

Several months ago,[1] we issued a preliminary report outlining the development of a new type of corneal contact lens. We have named this lens the "Microlens." This lens differs from the conventional Tuohy corneal lens in being thinner than its predecessor and smaller in diameter.

Since the original report, Sohnges, Dickinson and Neill have continued to exchange the results of their individual experiences in the fitting of the microlens. This report is based upon an aggregate of these experiences.

Originally, it was thought that the microlens should be made as thin as possible. Accordingly, some of the lenses produced for us in the laboratory of Dr. A. Mueller-Welt were as thin as 0.1 mm. (0.004"). These ultra-thin lenses failed to hold their shape when put in place on the cornea. In fact, they actually changed their curvature and clung to the cornea and failed to "lag" when the eye was moved or the lid was blinked. When these things occurred, it was usually not possible to obtain a good refractive correction. Also, the lenses produced a "burning" sensation after about one hour of wearing time. We remain of the opinion that the thinner lenses are more desirable from the standpoint of developing maximum lid comfort, but until such time as a plastic material can be developed which will maintain its shape even in very thin sections, it seems most desirable to manufacture the microlens only as thin as is consistent with the ability of the plastic material to hold its shape on the cornea.

After much clinical trial, we have found that the optimum thickness lies between 0.18 and 0.20 mm. With presently available plastics, of the type which can be injection molded, this is the minimum range of thickness which will permit the lens to hold its shape on the cornea. The lenses which we are now fitting, and which are available to all

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[1]The preliminary report was sent to the members of the Contact Lens Section of the American Academy of Optometry and was subsequently published in the Alumni Bulletin of P. S. C. O., March-April issue, Vol. 7, No. 6, pp. 12-14, 1954.

contact lens practitioners, are being manufactured by the laboratory of Dr. A. Mueller-Welt.[2]

We have experimented with microlenses in diameters of 8.0, 8.5, 9.0, 9.5, and 10.0 mm. The diameter which has proved most satisfactory is 9.5 mm. For some patients with unusually large pupils we have had complaints of the presence of a crescent-shaped shadow which appeared on movement of the eye. This phenomenon is caused by encroachment of the edge of the lens on the pupillary area as the lens "lags" during movements of the eye or lid. The use of a larger diameter lens will eliminate this problem. Less than 10 per cent of our patients have required lenses of 10.0 mm. diameter; the other 90 per cent have been fitted with lenses having a diameter of 9.5 mm. It is possible that a person possessing a very small pupil in conjunction with a small corneal diameter would be most satisfactorily fitted with a lens 9.0 mm. in diameter.

It is important in fitting the microlens to have the optimum relationship between the posterior curve of the contact lens and the anterior curve of the cornea. This relationship determines the amount of lens surface area in contact with the cornea and this, in turn, determines the amount of "lag" or "slip" of the lens on the cornea. The maximum "lag" occurs when the lens curve is much flatter than that of the cornea (loose lens). The "lag" approaches zero as the lens curve approaches that of the cornea (tight lens). A lens which has a long radius and is flat or loose in relation to the cornea has a minimum of bearing surface area on the cornea, and a lens which has a short radius and is tight in relation to the cornea has a maximum of bearing surface area.

When a lens is fitted so as to rest too tightly on the cornea, the increased adhesion and pressure will prevent "lag" and will interfere with the proper circulation of tears between the lens and the cornea. The resulting interference with the metabolism of the cornea will, after an hour or so of wearing time, produce a "burning" sensation which becomes progressively worse.

Where a lens is fitted so as to rest too loosely, the adhesive forces become inadequate and the lens "lags" excessively. This excessive lag and the increased amount of friction which develops on the smaller area of the cornea will cause an abrasion of the superficial epithelium to develop and may prevent the obtaining of good visual acuity during the refraction. A lens which is too loose may slide off the cornea onto the sclera, or it may even "pop" off the eye altogether when the eye is rotated.

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[2]Dr. A. Mueller-Welt, International Lens Laboratories, 140 Cadillac Sq., Detroit, Mich.

Sohnges and Neill use the keratometer to measure the corneal curvature, and on the basis of this measurement they decide on the first lens to be placed on the cornea. When, as is usual, the cornea is astigmatic, they use the measurement of the flattest meridian as a basis for deciding on the first lens. When the first lens has been placed on the cornea, they then evaluate the fit by observation of the amount of "lag." (A loupe or magnifier is helpful here.) Excessive "lag" is corrected by a tightening of the lens (shortening the radius) and a lack of "lag" is corrected by a loosening of the lens (lengthening the radius).

When the Tuohy lens was first introduced, it was suggested that the lens should be fitted so that its inside surface would be 1.50 diopters (0.3 mm.) flatter than the flattest meridian of the cornea. It has been our experience in fitting these lenses that this suggested amount of flattening is not sufficient and the those cases most successfully fitted have been fitted with lenses 2.00 to 2.50 diopters flatter than the lowest curvature of the cornea.

In the case of the microlens, it has been found that this lens must be fitted even flatter than the Tuohy lens. A review of the successful cases fitted to date by Neill indicates that 75 per cent of these cases were fitted with lenses which were 3.50 diopters flatter than the flattest meridian of the cornea. Two cases have been observed where the optimum fit was 5.00 diopters flatter than the cornea, while in only one case was the inside curve of the lens as little as 2.50 diopters flatter than the cornea.

While we cannot presume to state at this time just what it is that determines the degree of flattening which the lens must possess in a given case, we have noted that the amount of astigmatism is a factor and that the age of the individual may also be a factor, since younger corneas are usually softer and more compressible than older ones.

The keratometer is not used extensively in England, and for this reason Dickinson has been obliged to fit the microlens without obtaining a preliminary knowledge of the corneal curvatures. That he has been successful, points to the value of the observation of "lag" and the use of the fluorescein picture. Dickinson recognizes the convenience of the keratometer in fitting the microlens and in a recent communication states that he is endeavoring to obtain one of these instruments.

Following observation of the "lag," one drop of 2 per cent sodium fluorescein solution is instilled at the superior edge of the lens and the fluorescein pattern is observed with the aid of a Burton Magnifier equipped with ultra-violet tubes. A dark spot, surrounded by fluor-

escence, indicates the area of contact. The outline of this area is more or less circular in cases where the cornea has little or no astigmatism and becomes progressively more oval in cases of larger amounts of astigmatism. On the basis of the cases successfully fitted to date by Neill, it seems that the optimum diameter of the dark area is between three and four millimeters.

Among the cases seen by Neill, about forty per cent had previously been fitted unsatisfactorily with some other type of contact lens. In most of these cases the dissatisfaction resulted from short wearing time caused by the appearance of Sattler's veil. In a few cases the dissatisfaction resulted from irritation. All but one of these cases were satisfactorily fitted with microlenses. To date only four cases of all those attempted have been unsuccessful. Up to this time no effort has been made to fit a case of keratoconus with the new lens.

The office procedure which we use in fitting the microlens is as follows:

*1st Visit:* The first lens is selected on the basis of the keratometer reading as previously discussed. This lens is oberved both under white light and under ultra-violet with fluorecein. On the basis of this observation the lens is changed to give the optimum fit. The patient is instructed to keep looking downward during this visit, which lasts from two to four hours. Frequently, lenses which appear to be loose at first will tighten up after a period of time as a result of reduced tearing and blink rate (as the lids become more accustomed to the lenses) or as a result of compression of the cornea.

*2nd Visit:* The last lenses used on the previous visit are again inserted and are again observed over a two-hour period. Frequently, the cornea will stain with fluorescein on the first and second visits, and usually this staining (indicating a slight abrasion of superficial corneal epithelium) will be centered over the dark area (area of contact). If the fit is correct, this staining will diminish and finally disappear on subsequent visits. If the staining persists, it usually indicates that the lens is too flat. Usually, the blink rate and amount of tearing are reduced toward the end of this visit so that we can instruct the patient to practice raising his gaze to eye level.

*3rd Visit:* On this visit the patient is instructed in the procedure for inserting the microlens (resting wetted lens on tip of index finger and touching to the cornea) and in removing the lens. We first have him try to remove the lens by having him stare into his open palm and then pull the outer canthus toward the top of his ear. Frequently, this method of removal is unsuccessful because microlenses cling to the cornea more tightly than do conventional corneal lenses. If this method

is unsuccessful, the patient is then taught to remove the lens with a suction cup. After the patiert has satisfactorily inserted and removed his trial lenses, he is given a pair of trial lenses (of proper inside radius) to take home. He is instructed that for the first two or three days he is to insert and remove his lenses as often as possible and not to wear them for more than one hour at a time. Our purpose here is to develop dexterity in inserting and removing the lenses and to overcome the fear inherent in doing this.

After the patient has overcome his fear and developed his dexterity (usually 2 or 3 days), he is permitted to increase his wearing time at the rate of 15 minutes to one-half hour each day. When he reaches four hours of wearing time, three times each day (this takes from 10 days to several weeks), he is given an appointment for his fourth visit.

*4th Visit:* Since he has now reached the point where he can wear his lenses for four hours, three times daily, it is assumed that the patient has been satisfactorily fitted. We check the fit according to the criteria previously set forth and then proceed to refract the patient with the microlenses in place. Following this procedure, the patient is instructed to continue wearing his trial lenses and to continue to build up his wearing time, if possible, at a rate not to exceed 15 minutes daily, until his finished prescription lenses are ready and he is notified to call for his 5th visit.

*5th Visit:* The fit of the finished lenses is checked against the fit of the trial lenses. Visual acuity is checked. The patient is advised that there may be a brief period of adjustment due to the difference in the outside curvatures of the trial and prescription lenses. He is instructed to continue increasing his wearing time at the rate of 15 minutes daily so long as the last wearing time of the previous day was comfortable. In the event that this last previous wearing time was not comfortable, he is to hold his wearing time without increase until the discomfort is overcome.

We have attempted to set forth briefly here our experiences to date with the microlens. As our clinical experience increases we will issue further reports on our progress. Sohnges, Dickinson and Neill will meet in Munich on September 3, 1954, for a week of discussion and clinics on the microlens.

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# STEREOPHOTOGRAPHIC AND STEREOPHOTOGRAMETRIC REPRODUCTION OF THE CORNEA AND SCLERA OF THE LIVING EYE*

## AFTER THE METHODS OF DENCKS AND RZYMKOWSKY

Johannes Rzymkowsky
Translated by William P. Schumann†
Vineland, New Jersey

Contact lenses are transparent shells, as a rule made of glass, and lately also of plexiglas (plastics) which are worn under the lids on the eyeball by persons with poor eyesight and which through the correction of the ametropia improve the visual acuity.

A contact lens, Figure 1, lies with its optically effective part

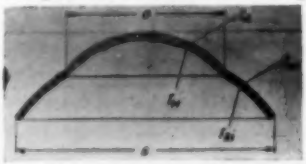

Fig. 1. The cross section of the contact lens. C is the diameter of the corneal part. S is the diameter of the total lens. $r_K$ and $r_H$ are the anterior and posterior radii of the corneal portion. $r_{sa}$ and $r_{si}$ are the outer and inner radii of the sceral rim.

C over the cornea and the pupil of the human eye. $r_K$ and $r_H$ are the anterior and posterior radii of that part of the contact lens. The scleral rim of the contact lens which should follow the contours of the sclera smoothly, have the anterior and posterior radii $r_{sa}$ and $r_{si}$ and are therefore of lesser curvature. Between the inserted contact lens and the cornea of the eye there forms a liquid lens created by tears, for whose effect the posterior or the eyeball adjacent radius $r_H$ is responsible.

For the wearing comfort of a contact lens the inside radius of the scleral rim $r_{si}$ is of greatest importance. Since the curvature of the ocular conjunctiva is not known, it is ascertained empirically through the selection method. For this reason we have the various trial sets. To obtain the best fitting contact lens through trial and error is rather time consuming and cumbersome, and its exactness depends on the number of lenses in the trial case. Furthermore they are of no use when we deal with an asymetric sclera.[1]

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To assure a more comfortable and exact fit it was suggested that an impression of the anterior surface of the living eyeball be made and from its form the true contact lens be created. Csapody in 1929 and Dallos in 1933 made known their method of taking impressions, which became known as the "constructive method."

Dallos[2] desensitized the eyes and used Negokoll for the impression. The patient was instructed to maintain a certain fixation. This method was not without faults, as it is possible that the eye might become temporarily somewhat deformed as the internal pressure of the eye is normally only 24 mm. of mercury. A further danger is present as the patient might press the lids together while an impression is being taken.

In 1940 Dencks and the author improved upon the procedure of Dallos by the use of photography. We were attracted by the idea that it must be possible to take a picture of the sclera with a stereo camera, exactly as a stereoscopic picture is taken from an aeroplane[3] for the purpose of aerial mapping, and that the two stereo images would lend themselves for stereomicrometric plotting. The curvatures so obtained would serve for the construction of the scleral rim of the contact lens.[4]

If the patient is an ametrope his correction is determined in the usual manner and the lens incorporated. The haptical fit of the contact lens with the optical correction should give us a basis free from objection for the selection and construction of the contact lens. It is obvious by the measurements that certain tolerances have to be taken into account, which should assure the patient comfort.

The first photographs of the living eye in this experiment were made on patients who already wore contact lenses, and we used a regular stereo camera 6x13 cm. of the type Stereo-Ideal with double extension bellow, an objective focal length of f = 9 cm., and a separation of 6.5 cm.

We selected for our first pictures orthochromatic plates and for illumination nitraphot flood light. In our first experiments we did not separate the lids of the patients. However, it was soon evident that even with the use of highly sensitive plates the exposure time was far too long, and no clear image of the sclera was possible; all negatives disclosed blurredness due to movement of the eye. Then too the lids covered a great part of the conjunctiva, so that a complete survey and measurement of the anterior portion of the cornea was impossible.

We then tried to expose the eye of the patient by separating the lids through lid clamps, Figure 2. However, their use was annoying to

Fig. 2. Part of a stereoscopic picture of the eye. Illumination with a nitraphot flood light. The lids are held apart with a lid clamp.

the patient, and cocain had to be used from time to time to keep the eye quiet. Both ways would have constituted a step backward in the field of photographic survey of the living eye, and for this reason we decided to try to take the picture of the eye with a flash bulb. This also enabled us to pull the lids of the patient apart shortly before the exposure, so that the anterior portion of the globe would be free and more visible. Figure 3.

Fig. 3. (Top) Part of a stereoscopic picture of the eye, using the Dencks-Rzymkowsky method of photography.
Fig. 4. (Bottom) Stereopictures of the human eye on a 6x13 cm. plate taken with flash bulb illumination. In this illustration the finger shown, throws a false shadow on the upper part of the sclera.

Before we attempted to take a picture of the living eye of a patient from a short distance with a flash bulb, we first photographed the enucleated eye of a pig because according to measurements of the Physikalische-Technische Reichsanstalt the momentary illumination of an Osram Vakublitz #2 is eight times the average illumination of the sun (60,000 Lux) at a distance of one meter.

We clamped the pig eye in an experimental tripod, and studied the qualifications needed for a good reproduction of the smallest details on the negative; also the selection of the correct opening of the diaphragm, distance, and the type of plates for the negative.

After those preliminary observations we took pictures first of the pig eye and then of our own eyes. We found that the Osram Vakublitz, when flashed at a distance of 80 cm. from the eye caused no damage. The picture was taken in a completely illuminated room, so that the eye was not dark adapted previous to the exposure. Aside from a short and hardly noticeable dazzle, we felt no after effects of any kind. We then included in our experiments the eyes of patients and at no time did anyone complain of discomfort. We obtained excellent photographs of the sclera, with great depth and sharpness of the fine arteries and veins of the conjunctiva. The stereopictures made it possible when viewed in a stereoscope, to obtain an objective opinion of the anterior portion of the globe of the eye, Figure 4.

Fig. 5. Part of a stereoscopic picture of an eye with flash bulb illumination. Placement of eye and finger is faultless. Isopan F-emulsion with Atomal developer gives a very good reproduction of the fine arteries of the eye, and therefore excellent observation points for the stereometric evaluation of this picture.

It was soon noticeable that for the evaluation of the measurements the exposure time of the stereo negative had to be very exact, and it had to be processed with a fine grain developer. The orthochromatic plate did not prove to be satisfactory and also was too slow, so we resorted to a panchromatic plate. The latter could not be over sensitized for red, in fact the sensitivity for red had to be of lesser degree, and fortunately this is found with the fine grain materials of the Agfa which are sold under the name of Isopan. The right selection of the materials for taking the picture is of prime importance for obtaining results by this method. The good reproduction of the arterial network of the sclera is shown in Figure 5.

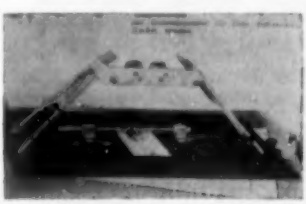


Fig. 6. Mirror stereoscope with pointer stereometer of Fa. Zeiss-Aerotopograph. G.m.b.H. Munich.

The stereometric evaluation of the two pictures is made from the negatives in a mirror stereoscope with a drawing stereometer, whose exactness is sufficient for our use, Figure 6.

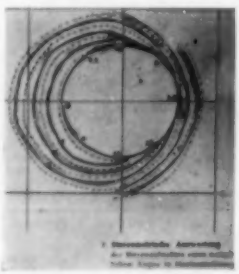
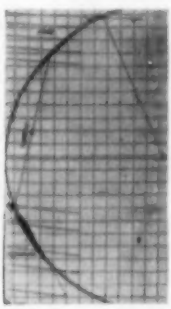


Fig. 7. Stereometric evaluation of a stereopicture of a human eye in horizontal cross section.

Figure 7 shows such an evaluation in horizontal lines. Every divergence or irregularity from the principal form of the frontal surface of the eye is immediately visible in the course and height of the strata of lines. In this picture the patient did not keep his sight focused on the point of fixation, therefore in the strata of lines the cornea is moved toward the side.



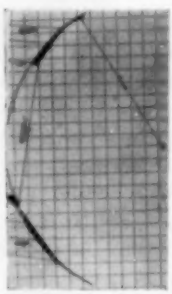


Fig. 8. (Right) Stereogram. Horizontal cross section. Towards the center of the iris diverted 1.6 mm. upward. On the basis of this stereogram the patient needs a contact lens whose radius of the inner scleral rim is 12 mm.
Fig. 9. (Left) Stereogram. Vertical cross section, toward the center of the iris diverted 1.9 mm. out. On the basis of the stereogram the patient would need a contact lens with a scleral rim radius of 12 mm.

Figures 8 and 9 give stereometric evaluations in the cross sections, Figure 8 representing a horizontal cross section and Figure 9 giving that of a vertical nature: yet the stereometric evaluation of the pair of images can be made in any meridian. The heavy black surfaces in these

figures indicate the photographed curvature deviations from the ideal contact lens. The line with arrowheads indicating 12 mm. indicates that for this eye a contact lens whose inside or posterior radius equals 12 mm. would be acceptable and comfortable.

In a few experiments where contact lenses were fitted by this method we found that wearing comfort was not always possible. This led us to the assumption that the contact lenses used, did not always have the scleral rim radius as indicated by the manufacturer. To substantiate our assumption we took pictures of some contact lenses stereoscopically, and to be able to read and obtain the stereometric measurements we covered the inside of the lens with lycopodium, on which we drew some lines with a needlepoint, Figure 10. On the

Fig. 10. Part of a stereo picture, of four different contact lenses. The inside of the lenses is dusted with licopodium to obtain points of measurements. A photograph of a millimeter rule is in the lower part of the picture.

basis of these stereometric photographs and measurements we showed the deviation of the radius from that as indicated.

The rules for obtaining pictures of the living sclera may now be reviewed. The patient comfortably seated in a well illuminated room places his chin and forehead in a headrest. The 6x13 cm. stereo camera is in front of the patient and moved to and fro so that the optimal distance between objective of the camera and the eye of the patient is 30 cm. This measured distance has to be exactly controlled, and any deviation from it has to be noted for the stereoscopic evaluation. Next to the patients eye is a millimeter rule placed vertically, which must be photographed simultaniously with the eye. Most suitable is a rule with black markings on a white background. The rule must stand vertically, Figures 3 and 4.

The patient is requested to look at the center of the camera, so he has a certain point of fixation easy to keep constant, and the iris

and pupil will be exactly in the center of the sclera while the picture is taken. At this point the lids of the patient will be carefully and slowly pulled apart as wide as possible. To obtain the needed sharpness in depth at this short distance, the diaphagms of the two objectives have to be set at *f*—25, and as the negative material we select Agfa Isopan 17/10 grad DIN fine grain.

The Osram Vakublitz #2 (flash bulb) with its reflector is placed on a tripod in back of the camera at a distance of 80 to 100 cm. from the head of the patient. It is best to secure the flash bulb tightly. If the release of the flash and the two shutters can not be connected for simultaneous action, a second person should be employed who will take care of camera and flash. The shutter set at "B" is opened, and the first person pulls the lid apart and gives the command for release of flash and shutter. After the picture is taken it is best to bathe the plate in a solution of Pinakryptol green 1:5000 in complete darkness for about 1 minute to desensitize the plate, and then develop it with a fine grain developer (best suited is Agfa Atomal) in the usual manner. A developing time of four minutes in most cases will be sufficient to obtain a soft negative of the conjunctiva needed for the stereometric evaluation. The hypo bath, washing and drying of the plate is done in the usual way. As soon as the plate is dry the stereoplate will be cut in two and viewed and evaluated.

The war with all its bitter results interrupted our experiments, and then death came to my coworker Dencks in 1946.

SUMMARY

A method is described for the fitting of contact lenses, which omits the impression method of the eye with Negokoll completely. A stereophotographic picure of the sclera of the eye is taken with the aid of a flash bulb, and the patient does not encounter the discomfort of lid clamps nor drops to desensitize the eye. The stereo pictures are evaluated photogrametically, and the corneal surface curves form the basis for the selection or construction of the contact lenses.

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## OPTOMETRY IS OPTOMETRY*

Optometry is optometry, is optometry, is optometry. This Gertrude Stein-like statement should be the creed of every optometrist. Optometry is not a junior edition of ophthalmology. It is not limited medicine. It is not a glorified form of opticianry. It is not a branch of education nor is it a portion of illuminating engineering, safety engineering, nor highway engineering, nor psychology, nor physiology. Optometry is the clinical application of physiological optics in its broadest sense.

*By Meredith W. Morgan, Jr., Optometrist, Ph.D., Member of faculty, School of Optometry, University of California. President, American Academy of Optometry

If these statements above are correct then the most professional optometrist is not he who most closely mimics the practice of ophthalmology. It is not he who teaches remedial reading, designs classrooms, or does a whole host of things that are related to optometry. The most professional optometrist is he who practices optometry to the best of his ability.

As stated, optometry is the clinical application of physiological optics. This means that the optometrist must be prepared to utilize the tools of physiological optics and be prepared to give equal emphasis to all the things he does: Examining for normalcy, refracting, dispensing, orthoptics, visual training, and referring.

Some optometrists choose willfully, or without thought, to emphasize some aspect of their activity above all others. Some believe refracting is the heart of optometry. These men either do not dispense or they neglect it frightfully or they apologize for it. Dispensing is an integral part of optometry.

Some optometrists emphasize dispensing. They become the seller of glasses and because of their obviousness they act as millstones around the neck of the profession as a whole. Legislatures, the courts, governmental agencies and others can well repeat, "How can I hear what you say when what you are is screaming so loud?"

Others believe orthoptics or visual training is the heart of optometry. At best these men over emphasize this aspect because they feel it is truly professional in that "treatments" are involved without an appliance being sold. At worst it is a method merely for increasing the net income per patient.

Few, if any, place the emphasis of optometry on the last point, that of referring patients. Somehow a stigma of inferiority seems to be attached to referring any patient out of any office. Most optometrists will refer cases of pathology, as they feel they should, but how about the other patients, those needing orthoptics, contact lenses, advice on lighting, help in remedial reading and a host of others?

It would seem that we now arrive at a contradiction in this presentation in as much as it has been implied that remedial reading, for example, is not necessarily a part of the field of optometry. Ordinarily this is so but there is no law which states that an optometrist cannot qualify himself to be an expert in this field. The point is that this requires additional qualification and this must be more than that obtained by reading a book or listening in on a few lectures. Optometry has been quick to condemn the medical specialist who has become such by use of the sign painter's art. We should not therefore be surprised when the condemnation is reversed.

Patients need not be referred only to other optometrists or to physicians or to ophthalmologists. Patients can be referred to remedial reading teachers, lighting engineers, etc. The optometrist who is doing his job sees to it that something is done about the patient's problem regardless of who it is that supplies the solution.

Optometrists, as a group, suffer from an inferiority complex. This seems to grow out of many factors, not the least of these is the limitation of the field of practice. There is a tendency to compensate for this by overaction in antagonism towards those professions which are related, a tendency to boast of great knowledge in a narrow field because of specialization, a general belligerency, and an attempt to increase the apparent size of the field by encompassing safety engineering, reading, etc.

A field of endeavor is not more or less professional and respectable because it is limited or unlimited. A profession is defined as an occupation requiring an education, involving judgment in addition to mere rules or laws. This does not mean that the need for education is required by law alone but that the very nature of the occupation itself requires an education. Normally speaking, an educated person is assumed to be one who knows more than just a set of rules. An educated person is able to exercise that illusive quality called judgment—he is able to think, to reason, to arrive at conclusions not set down in rules, to exercise intuition. The science of optometry thus qualifies itself as a profession but the question each optometrist should ask himself is, "Am I a professional optometrist?" If the answer is no, then that man is not only doing a disservice to his patients but he is also harming the profession in general and himself in particular.

This inferiority complex likewise shows itself in a tendency to blame others for the faults of optometry, i.e., optometrists must continue window displays, etc., because dispensing opticians have window displays. Optometrists have a difficult time because of the action of ophthalmologists. Optometry does not have an academic doctorate degree because of medicine. There is a fundamental fallacy here since there is the implication that optometry must outdo opticians and ophthalmologists and at the same time win the approval and acceptance of both groups. This is virtually impossible by definition. Optometry must win by itself acceptance by the lay public; not by tearing down other groups but by promoting and advancing itself. An academic doctorate degree will automatically accrue when educators and scientists, as a whole, recognize optometry as a separate field of learning and not just simply a field requiring technical excellence.

An optometrist must be proud to be an optometrist and not

apologetic. When a layman mistakes him for an ophthalmologist, he should not feel pride in finally winning acceptance but he should feel chagrin that his profession has not yet been clearly identified.

Pride in optometry will come as a natural consequence of a positive professional attitude on the part of the majority of optometrists. It must be realized by all that the leaders and educators in optometry find it difficult to maintain this positive attitude of mind when they must frequently be apologetic for the actions of the obvious nonprofessional practitioner.

MEREDITH W. MORGAN, JR.

## SPECIAL REPORT

# HOW TO STUDY VISION: A REVIEW OF SOME DIFFERENT APPROACHES*

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In preparing this paper, I felt at first that it was somewhat presumptuous of me, a psychologist, to speak directly on the subject of vision to a group of specialists in this area. On second thought, I was able to rationalize some justifications. After all, was not sensory psychology, and particularly vision, one of the oldest and most carefully documented chapters in psychology? And was it not by the very nature of things, perfectly right that it should be so? For vision is an area which is broad enough to embrace a number of different disciplines and important enough to justify concentrated efforts from many quarters.

All knowledge comes only through the senses, and those who would "know how they know" turn quite naturally to the contemplation of the senses as the originators of experience. The study of what and how we see concerns the clinician, the artist, the advertising expert, the engineer, and the educator as well as the scientist. And for each it poses a different problem.

*Read before the 54th annual convention of the Texas Optometric Association, San Antonio, Texas, April 26, 1954. For publication in the August, 1954, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

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My theme is the different approaches to the study and understanding of vision and, more specifically, the proposition that the orientation, or approach, one adheres to is a relative matter, dependent on the particular problem in the area of vision one is concerned with, arrayed, for example, on a dimension of complexity. To put it more concretely—if we are interested in absolute and differential thresholds, then we can reach acceptable levels of predictability and applicability if we restrict ourselves, both in techniques and theory, only to a limited visual system. However, if we are interested in how one sees complex visual configurations, then we must extend our concept of the visual system, both in techniques and theory, to reach the same degree of predictability.

Let us examine this argument from an historical perspective. When Wilhelm Wundt was formally inaugurating experimental psychology at his laboratory in Leipzig, in 1879, the physical sciences, particularly chemistry, were in their heyday. The Zeitgeist was appropriate for Wundt's grand design. As everyone well knew, particularly those who worked under Wundt, psychology was the study of consciousness, or mental content. All that was necessary was to find the elements of consciousness, measure them in terms of attributes or, as Boring later termed them, dimensions, and then combine these elements in a mental chemistry of consciousness. How clear and simple.

The first element Wundt undertook to study was sensation, starting off with vision. The attributes he proposed were quality, intensity, duration; and Titchener added clearness. Boring later changed them somewhat, obliquely adding protensity, extensity, attensity, and throwing out duration and clearness.

From pre-Wundtian days, Weber, at first, and then greatly elaborated by Fechner, psychophysical parallelism presented itself as the very way to measure the attributes of visual sensation. This principle of psychophysical parallelism believed in the essential identity of the mental world and the physical world of matter. The transition from one to the other could be established by discovering the relationships which exist between the two sets of data. All visual sensations (all mental processes Fechner believed) would thus be measurable in terms of their stimuli, and the Weber-Fechner Law, S (sensation intensity) $= K_{\log} I$ (stimulus intensity, energy ideally), mathematically stated the relationship. What was needed now was measurable units for specification of the sensation or mental content, and units for the stimulus specification.

But how were they to get at mental content? This again was simple. Make sure you get a trained subject who can reduce his ex-

periencing to elemental sensations and then ask him what he is experiencing with changes in the stimulus situation. The unit of mental content we can use is a jnd, *just noticeable difference*, which is experienced with a change in the physical stimulus. And so a technique was born—the method of introspection—which could be used with the theory of psychophysical parallelism. And science went gloriously forward. Students in experimental psychology laboratories spent their time experiencing sensations (visual that is) and laboriously plotting their psychophysical results. Boring, incidentally, wrote his doctoral dissertation under Titchener on the experiences of his alimentary canal, while others pricked their skin and strained their eyes.

The specification of the physical stimulus is involved indeed. Take the case of intensity of light. It can be expressed in terms of luminous flux or amount of light emitted, luminous intensity or candlepower. Another way of expressing stimulus intensities is in terms of actual illuminance of the retina, once the light has reached the eye and its amount has been cut down by the pupil. In such cases intensity is specified in terms of *Trolands*, named after a famous experimental psychologist.

Essentially, then, this first approach consists of establishing relationships between, on the one hand, elements of consciousness, visual sensations, expressed in units of *jnd's;* and, on the other hand, various aspects of the physical stimulus, such as hue, intensity, saturation, expressed in their appropriate units. These relationships can further be examined under various observer and stimulus conditions.

What has become of this approach? First and foremost, we must not forget that it initiated the experimental investigation of that nebulous nonentity, mental content. Instead of talking and arguing about how many teeth were in a horse's mouth, as Aristotelian students did, we now looked in the horse's mouth. It has also and is continuing to contribute important data in many important areas, of which some are light and dark adaptation, color mixing, color blindness, rod and cone vision, and many others.

But as we sought to extend our horizons, there were difficulties. In fact, there were difficulties even with the basic relationships. If an initial intensity is designated I and the just noticeably different intensity is called $I + \Delta I$, we should find that the ration $\Delta I/I$ would vary in a systematic way over the range of visible intensities. The Weber fraction, $\Delta I/I$, was originally thought to be a constant one ("Weber's Law"). It is roughly so for the middle ranges of illuminations but deviates very considerably at the two ends of the scale. At the lowest

intensities the fraction is nearly 1/1, while at the highest intensities it decreases to as little as 1/167.

Also the correspondence between wave length and visible hue is not an entirely constant one. Hue is partially determined by intensity. Except for certain invariable points in the spectrum, all colors, upon being brightened, shift slightly towards either yellow or blue.

But these are by no means the more important difficulties. When we are concerned not with unitary physical stimulus dimensions, but with more complex stimulus situations, this theoretical approach seriously breaks down and we are left in an abyss of uncertainties. To the rescue came the Gestaltists. And this is the second approach I would like to consider.

What are some of the difficulties I had reference to? One case noted back in 1890 by Ehrenfels had to do with a different sense modality—musical tunes. When a tune is transposed into another key, it is made up of different notes and different pitches, which means different frequencies of vibrations; but the tune is still the same and easily recognized. The Gestaltqualität, or form quality of the tune, does not depend upon the individual notes and their frequencies of vibration, but rather on the patterned interrelation, their configurational properties.

Take another familiar case. If we take two small test patches from a sheet of light gray paper and put one on a white background and the other on a black background, the two gray patches will no longer look alike. The one placed on a white background will look darker than its twin on a black background. The two inducing regions, one white and one black, have effected the experienced color of each test patch. The change in color of the test patch is away from the color of the inducing area. White darkens the gray and black lightens it.

The physical stimulus, the test patch, is exactly the same in both instances; but we see it differently because of the contextual configuration it is in, or, as a good Gestaltist would say, the field situation. Finally, take the case of two bars of light, about an inch wide and four inches apart. We flash one light on and then the other. If we keep the time interval between flashes somewhere between 60 and 200 milliseconds, phi movement is seen; that is, pure movement divorced from an object. And the student, who has laboriously been doing all this, again proves Wertheimer correct. The light stimuli are exactly the same but, because of their contextual relationship to each other, we have seen a completely new phenomenon—movement.

In place of the combination of elements into a mental chemistry,

the Gestalt position uses the concept of dynamic field, all parts of which are interacting from the moment of peripheral stimulation. This total form is a primitive physiological process so closely bound-up with the sensory receptive process that introspectively no distinction can be made between sensation and perception. This approach minimizes learning or past experience factors and regards the receptive process and brain as being formative or configurational. Autochthonous "laws of organization," dependent on stimulus field forces, are the determinants of stable configuration.

The Gestaltists had three main tenets: *one*, some relationships are introspectively as well as epistemologically irreducible; *second* was the doctrine of wholes—since there are wholes, and these are primary to the analysis into parts, science cannot be "additive, elementaristic, or mechanistic"; and the *third* tenet, an "isomorphism" (that is, the same thing in different forms) is held to exist between an individual's brain field, his phenomenal field, and a part of his physical environment.

The Gestaltists made of sensation and perception one—there was no difference. Their subjects were required not to experience introspectively the elemental sensations, but simply to observe what comes naturally. Students in experimental laboratories now spent their time looking at circles, and dots, and lights, trying their best to keep everything together. All this was directed toward establishing the laws of organization in the external stimulus field which impose a stable perceptual organization through the receptor processes.

There have been many laws of organization developed, but I will name only a few. *Proximity:* objects close together tend to be seen as a group. *Similarity:* if a situation comprises several distinct kinds of stimuli, those which are alike will tend to be grouped or organized together. *Closure:* in most cases, grouping or organizing tends to favor simple closed designs.

There are many more, of which the law of Prägnanz is probably the most general. In complex stimulus situations we tend to see the grouping or organization which is as simple, as complete, as good as possible, which expresses some characteristic fully. A near-circle is seen as a true circle. If one of the Müller-Lyer figures is seen as consisting of two things standing apart, the apartness will be exaggerated by the observer. If the other Müller-Lyer figure is seen as a single compact object, the compactness will be exaggerated.

As you see this Gestalt approach is concerned with different problems. Instead of experiences of brightness, or color, or saturation, the concern was with more complex stimulus situations, tridimensional vision, configurations, movement, and so on.

What have we gained from this orientation? For one thing, the arbitrary and artificial distinction between sensation and perception was done away with. We experience with our brain through our eye, and the distinction between sensation and perception cannot be drawn at the retina, or at the optic chiasm, or even at area 17. It is a unitary process of visual experience which must take into account the functional interrelations of all the parts. Further, the visual experience is an organizational process which does not depend entirely on, for example, whether the rays of light fall in front of or in back of the retina, but also on the contextual pattern they produce in the brain.

The Gestaltists stressed the nature and characteristics of the external physical stimulus situation; they believed that it imposes an innate pattern or organization upon the brain, and they were right up to a point, but only up to a point.

And this brings us to our third approach, the learning and motivational inner field forces, as they affect the visual process. Let me first point out some difficulties with the Gestalt position. When a rectangular figure is projected upon a wall and seen from an angle, it is seen as a rectangle, even though the observer is at one side, so that his retinal image is that of an irregular trapezoid on the wall; it is seen as a trapezoid, even though the eye is in line with the projector so that the retinal image is that of a rectangle. Our perception is accurate, so far as reproducing what is projected upon the wall is concerned, but it is not faithful to the image furnished by our sense organs. A correction is made for the fact that what we see is projected upon a flat surface. One interpretation is that we have learned what rectangular figures look like when seen at an angle, so that our perception corresponds in both cases to the projected picture, not to our retinal image. This is an achievement of perception that comes about through learning.

In another case, consider a rectangular white card which is ambiguous as to size by placing a functional reduction screen in front of it. If you tell the subject he is looking at a calling card, he sees it at one distance. If you tell him he is looking at a business envelope, he sees it at another distance. Spatial vision thus depends to some extent on the observer's familiarity, learning about, the stimulus he is viewing.

Nowhere is the effect of learning on perception more dramatically illustrated than in Senden's collection of data.[2] His monograph is a compilation of all published reports on the vision of the congenitally blind given sight by a surgical operation after the patients were old enough to talk to the examiner and describe what they saw. The course of perceptual learning in these patients was gradual, proceeding from a dominance of color, through a period of separate attention to

each part of a figure, to a gradually arrived at identification of the whole, an apparently simultaneous instead of serial apprehension. Figure-ground segregation is good at the initial occurrence of human vision, but the perception of a square, circle, triangle, or of a sphere or cube is very poor. When the patient first gets to the point of naming an object promptly, the recognition is destroyed by putting the object into a new setting or by changing its color. The perception of pattern is specific and limited at first, generalized only with further practice, and in these cases there is no support whatever for the idea that, when a pattern is recognized at one angle of regard, it will be at once recognized in any other. The patient who had learned to name a ring showed no recognition of a slightly different ring; having learned to name a square, made of white cardboard, he could not name it when its color was changed to yellow or when the cardboard was turned over; and so on.

It is possible that the normal human infant goes through the same process, and that we are able to see a square as such in a single glance only as the result of complex learning. The notion seems unlikely, because of the utter simplicity of such a perception to the normal adult. But subjective simplicity and immediacy may be very deceptive as an index of physiological simplicity.

We cannot, of course, accept Senden's data without further collaboration. There is some evidence in Riesen's[6] work with chimpanzees raised in darkness to substantiate this position, and Hebb at McGill University is now doing very extensive work with dogs raised in darkness.

There is an ever increasing body of data which points to the conclusion that perception is not a univocal function of exteroceptive sensory stimulation. Visual information may be pooled with proprioceptive and interoceptive components, and these interactions are in turn influenced by learning processes.

The Hanover Institute Demonstrations[3] have revived an interest in perception which some psychologists have termed the "New Look." Essentially this approach holds that what we perceive depends upon the kind of organisms we are, as well as upon the kind of stimulation the outside world provides. There is an interaction between within-the-organisms factors and within-the-environment factors.

One goal of perception is the achievement of environmental stability. The organism seeks a perceptually stable environment in parallel fashion to the way in which it seeks an internally stable environment. For example, were it not for this achieved stability, the visual world would move as you move your head from side to side.

In the conflict for stability, the larger framework (for example,

horizontal and vertical frames of reference), will win over the smaller one (size constancy of objects). The goal of stability in perception is better served by a stable frame of reference than by a stable object. On those rare occasions when the cues to distance are misleading, we follow them rather than the cues from objects of familiar size.

A second goal of perception is definiteness. The organism strives to see objects as something, to achieve clarity, to structure into figure-ground relationships. We achieve clarity in ambiguous situations by seeing objects of a definite size and at a definite distance, even though cues are ambiguous. Ambiguity is resolved through familiarity, both with identifiable objects and with cues to distance. For example, in the reversible figures situation, definiteness is achieved at the price of stability. The ambiguous figures keep changing, but they always assume a concrete-thing-quality.

A great many perceptual experiences can be understood by considering the perceiving person to be a statistical machine capable of quickly estimating probabilities. That is, each of the cues presented in the stimulus situation is related to past experiences. Past experiences provide a kind of table of probabilities according to which estimates are made.

There is one final point to be made. Where the stimulus conditions are both ambiguous and varient, that is, where they do not impose a stable organization of their own, then so called "central processes," in terms of perceptual attitudes, mental sets, need systems, and special abilities, play a more dominant role.

It has been shown in a great number of studies,[1, 5] that emotional loadings of stimuli may modify perception, again distorting or contradicting what would be predicted from the simple frequencies of past experience. Some stimuli are threatening, anxiety-producing; others are reassuring, relieving of anxiety. Faced with the same external stimuli, subjects will perceive them differently because of the emotional experiences that these stimuli tap. Gardner Murphy has gone so far as to say: "the perceived world pattern mirrors the organized need pattern within."[4]

What have I tried to say? Vision, what and how we see, can be approached from many avenues. And I have concentrated upon one dimension of this approachability—the complexity of the problem you seek to understand, the complexity of the visual experience you seek to explain. At the present stage of our knowledge, there are no all-embracing theory which can handle everything. There have evolved theoretical frames of reference and methodological techniques which can

handle, at acceptable levels of predictability and applicability, certain aspects of vision. When we extend them beyond their limits, they are no longer useful.

You have undoubtedly noted that, as we went on in our presentation to consider visual experiences of greater complexity, the theories and techniques became less rigorous and less quantitative. This is the price we must pay. At the present stage of our knowledge, we can be more rigorous about less complex problems, or less rigorous about more complex problems. What we must not do is to assume rigor and quantification where it does not exist.

I, by no means, want to paint a pessimistic picture. For vision is one of the oldest chapters in the science of man, and we can look forward with great expectations to the evolution of a closer approximation to the truth.

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## CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

### THE TORONTO ACADEMY MEETING

The 34th Annual Meeting of the American Academy of Optometry will be held at Toronto, Ontario, Canada, December 11-14, 1954. The convention headquarters will be the Royal York Hotel.

This will be the first meeting of the Academy to be held in Canada, and Canadian Academy members are looking forward to serving as hosts to the members from the States and Europe as well as to the many special optometric guests from the nine provincial optometric associations in Canada. The Toronto Host Committee Men are: Dr. George

W. Keevil, Chairman, Dr. Irving Baker, Dr. E. J. Fisher, Dr. W. S. Long, Dr. C. A. Taylor.

Dr. Edward J. Fisher, Dean of the Ontario College of Optometry, Toronto, points out that Acedamy members attending the meeting in Toronto will probably have warmer weather than is usually had in Chicago in mid-December. Toronto has little wind or snow during that month, and the temperatures should vary between 40 degrees and 10 degrees. Dean Fisher hopes that all who attend the Academy meeting will take time off from the four day paper packed educational program to visit the Ontario College of Optometry. The traditional welcome mat will be out at the college, and all are invited.

Dr. John D. Perry, Jr., Chairman of the Papers and Program Committee, reports that this Toronto meeting should be an outstanding optometric educational event. His committee hopes to present a symposium on the Turville Infinity Balance test and also one on the use of the gradient. The Contact Lens Section will present a clinical demonstration of the new "Microlens" and Dr. John Neill of the faculty of the Pennsylvania State College of Optometry is expected to report on his clinical conference with Dr. Wilhelm Sohnges in Germany, from which place he will have just returned. In addition to the foregoing, Dr. Perry reports that the following papers have already been scheduled.

Dr. Fred Sinn, "Optical Limitations in the Correction of Astigma."
Dr. Max Schapero, "The Effect of the A.C.A. Ratio and Fixation Distance of the Angle of Anomaly."
Dr. John Zettel, Jr., "Evolution and the Human Eye."
Dr. Wm. G. Walton, Jr., "Analysis of One Thousand Consecutive Clinical Records."
Dr. Irving Vics, "Case Reports on Subnormal Vision."
Dr. Darrell B. Carter, "Changes in Fixation Disparity and Heterophoria During and After Wearing of Prism."
Dr. Meredith W. Morgan, "The Stability of Heterophoria."
Dr. William P. Schumann, "The Practical Demonstration and Application of the Objective Determination of the Visual Acuity on the Basis of the Optikinetic Nystagmus."
Dr. Sylvester K. Guth, "Lighting Levels for the Forgotten Man."
Dr. Francis A. Young, "Myopes vs. Non-myopes, a Comparison."
Dr. Merrill J. Allen, "The Stimulus to Accommodation and Some Practical Implications.
Dr. Glenn A. Fry, "Perceived Curvature of Surfaces Normal to the Primary Sagittal Line."
Dr. Robert E. Bannon, "Physiological Factors in Multifocal Corrections."
Dr. Ingeborg Schmidt, "A Sign of Manifest Heterozygosity in Carriers of Color Deficiency."

In addition to these, other papers will be reported on in following issues of this journal.

This meeting is the outstanding optometric educational event of the year, and members should plan to be present. Hotel reservations should be made now, by writing directly to the Royal York Hotel, Toronto, Ontario, Canada. The dates are December 11-14, 1954.

## C. C. O. MOVES TO ILLINOIS TECH CAMPUS

In September the Chicago College of Optometry will be fully moved from the old North Larrabee Street location to its new buildings in Technology Center on South Michigan Avenue in Chicago.

A modern new science and classroom building has just been completed and a new clinic building has been remodeled. This work has been done at a cost of approximately $300,000. All fall term undergraduate professional courses will be given on the new campus. Students wishing to live in school dormitories and apartments will have these provided for them by the Illinois Institute of Technology on the campus, and optometry students will also have the full use of other Illinois Tech college faculties, such as cafeterias, college shopping center, health and recreation services, chapel and sports. The new address of Chicago College of Optometry is 3241 Michigan Ave. S., Chicago, Illinois.

## NORTH CAROLINA CHAPTER

The North Carolina Chapter of the American Academy of Optometry met on June 27, at the Robert E. Lee Hotel, Winston-Salem. A symposium on glaucoma was presented by two ophthalmologists, Dr. H. C. Ennis and Dr. L. B. Holt. At the election which followed Dr. Robert J. Pearce, Greensboro, was elected president of the Chapter. The other officers are, Dr. Jules S. Deans, North Wilkesboro, vice-president; Dr. Dorothy L. Calhoun, Forest City, secretary-treasurer; and the following to serve on the executive council, Dr. M. Katzin, Jacksonville; Dr. G. C. Hodgins, Raleigh and Dr. H. L. Toms, Concord. The next meeting of the Chapter will be in the Fall.

## USAF ASSIGNS OPTOMETRISTS TO INDIANA UNIVERSITY

Captain Paul W. Lappin and Lieutenant Lester R. Loper, optometrists in the Air Force (M.S.C.), have been assigned to study at Indiana University in the new graduate program in physiological optics. This assignment is under sponsorship of Air University, Institute of Technology, USAF. Captain Lappin is a graduate of the Massachusetts College of Optometry, Lieutenant Loper is a graduate of the Pennsylvania State College of Optometry. Both have been serving as optometrists at Air Force Base Hospitals in Texas. The graduate program in physiological optics at Indiana University is under the direction of the faculty of the Division of Optometry.

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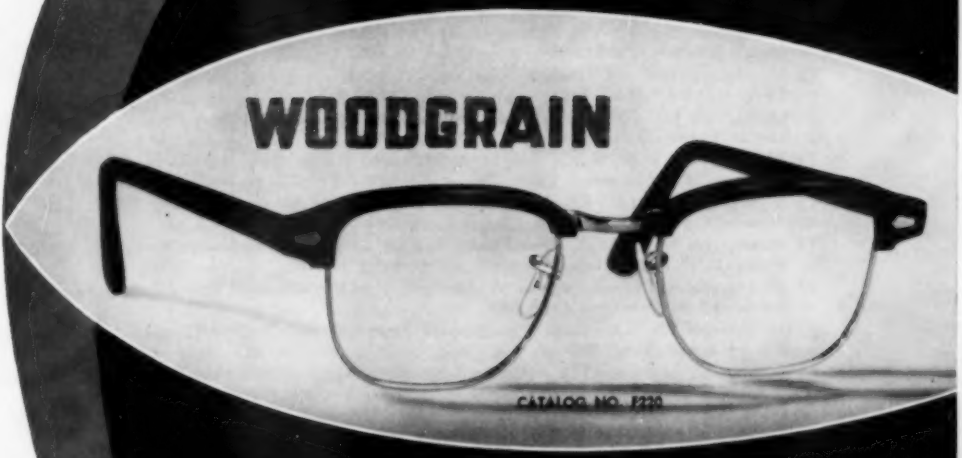


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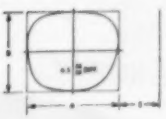

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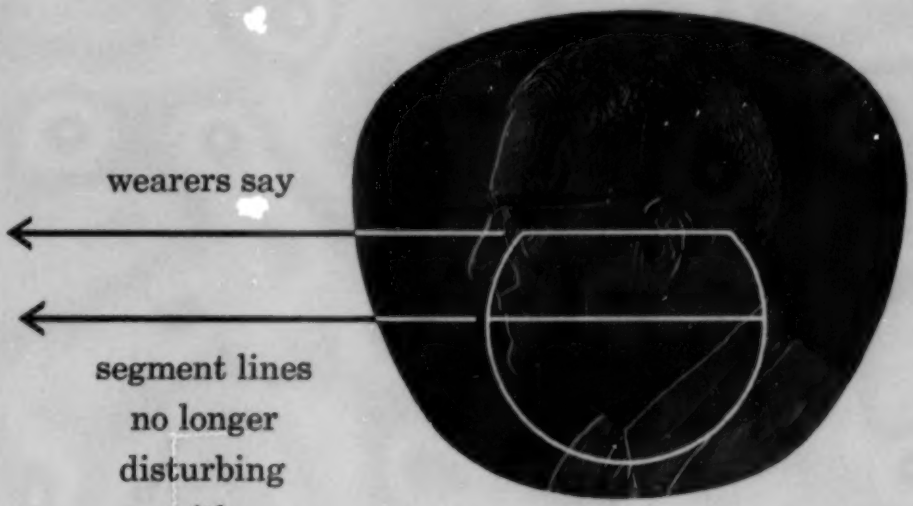

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